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BIDS FOR THREE 16,000-TON BATTLESHIPS have been called for by the Navy Department. The dimensions of the vessels will be: Length on load water line, 450 ft.; extreme breadth at l. w. l., 76 ft. 10 ins.; trial displacement, 16,000 tons; draft at trial displacement, 24 ft. 6 ins.; full load draft, 26 ft. 9 ins.; bunker capacity, 2,200 tons. The main battery will consist of: four 12-in. rifles mounted in pairs in two turrets, one forward and one aft; eight 8-in. rifles, in pairs in four turrets, two forward and two aft; twelve 7-in. rifles, in broadside on the gundeck. The vessel will carry a complete equipment of rapid-fire and automatic guns. The main armor belt is 9 ft. 3 ins. wide and 9 ins. thick; the casemate armor is 7-in., while the 3-in. rapid-fire guns are protected by 2-in. nickel steel. The engines are to be four-cylinder triple-expansion vertical engines, the two sides combined having a power of 16,500 HP. indicated, using 250 lbs. steam pressure, at 120 r. p. m. Twelve B. & W. boilers with 46,750 sq. ft. of heating surface will supply the steam.

AN ORE PIER OF UNUSUAL SIZE is being built at Escanaba, Mich., by the Chicago & Northwestern Ry. This pier will be 1,920 ft. long, 52 ft. wide and 71 ft. high from the surface of the water to the base of rail. It has 320 ore pockets, with an aggregate capacity of 80,000 tons of ore.

COAL BRIQUETTING MACHINERY is to be installed by the San Francisco & San Joaquin Coal Co., of San Francisco, the high price of coal there rendering briquetting profitable. The briquetting presses will be driven by electric motors arranged to give any desired speed from 20 revs. per min. to 350 revs. per min. in about 15 steps. Two 40-HP., slow speed, 500-volt, direct-current motors have recently been purchased for this purpose from the Westinghouse Electric & Mfg. Co., together with speed-controlling rheostats designed to vary the speed of the motors within the above limits. The controllers will allow the motors to be operated continuously at any of the speeds.

A PLATE ROLLING MILL to produce plates 140 ins. in width is reported under erection by the Carnegie Steel Co. It is said to be the largest plate mill in the world.

THE GREAT NORTHERN R. R. TUNNEL at Seattle, Wash., has been begun. The earth at the portal facing Puget Sound is being "hydraulicked" away. It is estimated that two years will be required to complete the work.

THE YAK TUNNEL, Leadville, Colo., has just been completed. The tunnel was started in 1890, for mine drainage and prospecting purposes, and has a total length of 11,000 ft. The cost is said to have been $1,000,000.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision on the Intercolonial Ry., near Windsor Junction, Nova Scotia, on April 11. An eastbound express passenger train ran into a westbound fast freight, which had run past the siding where it was due to wait for the express. In the wreck four men of the train crews were killed and several others injured. The driver of the freight train is said to have disregarded both his orders and the signals; no explanation for this is known.——On April 10 an engine on the Central Railroad of New Jersey overturned at Elizabeth, N. J., and three men of the crew were killed by being buried under the wreck. It is thought that a soft spot in the track caused the engine to overturn.

A DYNAMITE EXPLOSION killed two men and seriously injured two others, April 14, in the Washington tunnel of the Pittsburg, Toledo & Western R. R. Co., at Pittsburg. From newspaper accounts it appears that a blast hung fire, and when the foreman with another man went in to the heading to see what was the matter the charge went off, killing both men.

THREE DAM FAILURES IN THE WEST have been reported within the past three weeks. On March 29 or 30 the Concow dam, located 20 miles north of Oroville, Cal., gave way as the result of heavy rains. The dam was owned by the Spring Valley Mining Co., and was used for hydraulic mining. No data regarding its character were given, further than that it had a spillway 75 ft. long.——About the same date the Columbian dam, located at or near Newcastle, Cal., failed, causing a loss reported at $10,000. This structure stored water for irrigation.——On April 11 a dam near Olothe, and 15 miles from Delta, Colo., gave way, casing damage estimated at $50,000. It formed the Boney reservoir.

A 12-INCH. GUN BURST on the battleship "Iowa" during target practice off Pensacola, Fla., on April 9. Full service charges of smokeless powder behind explosive shells were being used. On its third shot for the day the port forward 12-in. gun had its muzzle end blown to pieces. Fragments passing down through several decks below killed three men and wounded several others. No one in the turret was even injured. It was thought at first that the shell had burst within the gun, but Admiral Higginson, reporting on the accident, says:

It does not appear that this accident was caused by the bursting of the shell, as some witnesses stated that they saw the shell strike near the target. The inner tube presents a fracture, but on none of the pieces into which the muzzle of the gun broke up are the grooves indented or scored, as in the case of a bursting shell.

The conditions surrounding the accident are described as follows in his report:

Third shot no unusual explosion; muzzle was blown to pieces from one foot within. Clear and regular break. Remainder of tube showed 22 cracks about 6 ft. No sign excessive pressure on record. No escape of gases at breech; no hang fire. Primer extracted perfectly; not damaged. Condition of loading and firing normal. Gun has been fired 127 times. Full charges smokeless powder. No serious defects are known to have existed in gun.

The gun was built in 1895, and was considered good for at least another year of service. The damage to the vessel is considerable.

A CIVIL SERVICE EXAMINATION for engineer draftsman will be held on April 21 by the United States Civil Service Commission. From the eligibles resulting from this examination it is expected that certification will be made to vacancies in the position of engineer draftsman in the office of the supervising architect, Treasury Department, at a salary from $1,400 to $1,600 per annum. Promotion to higher salaries will depend upon the efficiency of the appointees. Applicants for this examination will be required to show that they have had at least one year's experience and graduation from a technical school. This examination is open to all citizens of the United States who comply with the requirements. Competitors will be rated without regard to any consideration other than the qualifications shown in their examination papers, and eligibles will be certified strictly in accordance with the civil service law and rules. Persons who desire to compete should at once apply to the United States Civil Service Commission, Washington, D. C., for application Forms 304 and 375 and a copy of the Manual. The application should be properly executed and filed with the United States Civil Service Commission at Washington. The exact title of this examination as given at the head of this announcement should be used in the application.

ATTACKS ON PASSAIC VALLEY TRUNK SEWER bill, passed by the New Jersey legislature, appear to have begun in earnest. The aldermen of Paterson have passed a resolution to retain Ex-U. S. Attorney-General John W. Griggs and other Paterson lawyers to test the constitutionality of the act. A bill has been introduced in the New York legislature providing for the appointment by Governor Odell of a commission of five to investigate the effect of the proposed outlet into New York Bay upon the waters thereof. The commission would serve without compensation and would have until Feb. 1, 1904, to make its report. Finally, it is declared that the bill providing for the construction of the sewer, as signed by Governor Murphy, did not contain all the amendments passed by the legislature, and that a special session of the legislature will be held on April 21 to reenact the bill.

AN ACT TO PROTECT THE WATER SUPPLIES of North Carolina has been passed by the legislature of that state. It is printed in full in the Bulletin of the North Carolina Board of Health (Raleigh, N. C.,) as "a great improvement over an act with a similar title passed two years ago. The present act first declares that every agency

selling water to the public for drinking and household purposes, shall take every reasonable precaution to protect from contamination and assure the healthfulness of such water

and then repeals public and private charters inconsistent therewith. Every water-works must make at least a quarterly sanitary inspection of the drainage areas of any surface water supply, except that "large" rivers or creeks with a minimum daily flow of more than 10,000,000 gallons are not covered by the act, and of such large streams as must be inspected only the 15 miles (apparently meaning in length) next above the intake, need be inspected. When there is reason to fear the infection of a water supply from any particular locality in such drainage areas as have been described the local board of health, or if none then the county superintendent or the state board of health, may order a monthly inspection, and a weekly inspection may be ordered by the same authorities whenever there is special reason to fear a local infection of typhoid fever or cholera. Quarterly chemical and monthly bacterial examinations of all water supplies are required, the samples to be drawn from faucets, packed, and shipped, according to instructions of the state board of health. The examinations are to be made by the board just named, at the expense of the water-works involved, and for bacterial examinations $5 each may be charged. As a check on local authorities and companies, the state board of health is authorized to make sanitary inspections and water analyses at its discretion, to notify the proper authorities of dangerous conditions, and, in case proper steps to remedy them are not taken in 30 days, to have published in one or more local papers "a plain statement of the facts for the information and protection of the citizens using water." Pollution of public water supplies is prohibited with a specificness not often found in state legislation.

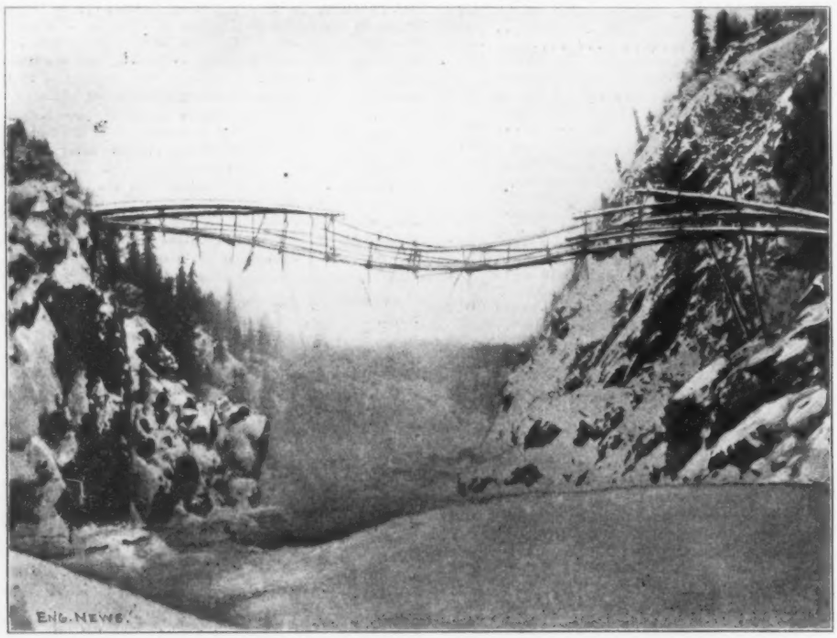
THE PROPOSED BITUMINOUS MACADAM PAVEment on Seventh Ave., between 110th and 120th Sts., New York City, is alleged by the Barber Asphalt Pavement Co. to be in violation of a clause in the city charter prohibiting the use of patented materials under circumstances preventing competition. The company named has secured a preliminary injunction restraining the city from contracting for the pavement until the court passes upon the merits of the case.

ELECTRICAL OPERATION OF MAIN-LINE railways in Switzerland is to be studied by an association just formed. The principal electrical companies of the federation, Oerlikon, Brown-Boveri, Alioth, Rieter and several others, and the technical department of the Swiss state railways have formed this association and will work together in studying the subject. The plentiful water power available in that country, the fact that coal must be imported, and the small area under consideration, renders the proposition of electric traction on the Swiss railways especially attractive. The movement to form this study association originated with the Swiss Electrotechnical Society. The present organization of the study association comprises as President, Mr. Flury, General Manager of the Swiss Federal Railway; as Vice-President, Dr. Tissot, of Basel, and as Secretary, Prof. Wyssling.

## AN EARLY AMERICAN CANTILEVER BRIDGE.

In our issue of March 19 we illustrated a primitive cantilever bridge in India built with heavy logs, to carry a footpath across a rocky gorge. We reproduce herewith a photograph of a primitive American cantilever bridge which we have received from Prof. John Galbraith, M. Can. Soc. C. E., of the School of Practical Science at Toronto.

Prof. Galbraith writes that he received the photograph from Mr. Wm. Murdock, C. E., of Toronto, who was engaged on the location of the




CANTILEVER BRIDGE BUILT BY INDIANS OVER TOMAQUA RIVER, BRITISH COLUMBIA.

Canadian Pacific Ry. in the late '70's. The bridge was built by Indians across a gorge on the Tomaqua River in British Columbia. In boldness of execution it certainly far surpasses its Asiatic rival which we showed a month ago. No engineer can examine the structure without a certain feeling of interest and admiration for the unknown Indian whose untutored brain conceived the design of this structure, and whose skill and daring in erecting it must have been indeed remarkable, when it is remembered with what primitive tools the work must have been done.

## METHODS AND COSTS OF PILE PULLING AND PILE BLASTING.

Recently a correspondent asked whether he had been duped or not by a contractor's foreman who professed to be unable to pull a pile driven only a few feet into the ground. The foreman had fastened the hammer rope of a land pile driver to the pile and the engine had shown its inability to start the pile. Was there a "trick" played by the foreman or not? We incline to think there was. In the first place the ordinary land pile driver engine cannot lift more than 5,000 lbs. on a hammer rope unaided by pulley blocks or other gearing; and a pile needs to be in the earth only a very short distance to have a frictional resistance exceeding 5,000 lbs.

The fact of the matter is that the pile driver foreman probably knew very well what he should have done to pull that particular pile, had he wished to do so. A double sheave block, or possibly a single sheave block chained to the pile, with corresponding blocks fastened to the upper cross bar of the leaders would doubtless have served to so "multiply" the engine pull as to start the pile. After starting it, a considerably less force serves to pull it.

A member of our editorial staff was at one time interested in a contract involving the removal of some 1,200 piles from an abandoned dam in a river bed. The methods used in removing these piles and the cost of the work may be of interest.

The work consisted in removing piles which had been driven to depths ranging from 6 to 27 ft. The piles had been cut off about a foot above the surface of the water, and the river was for the most part not over "waist deep" in low water, and about 600 ft. wide. It was found that the piles had been shod with heavy cast-iron conical shoes, and in a few cases the shoes had been displaced in driving. The river bed was gravel, underlaid by clay, and driving had evidently been very hard, as many piles were found which had been broken off underground.

### A SWEEP PILE PULLER.

When the work of pile pulling was begun it was decided to use an ordinary sweep stump puller, shown in Fig. 1. This machine consisted of an 8 × 10-in. yellow pine sweep, S, 24 ft. long, one end, A, of which rested upon the ground, while the other end, B, was provided with an axle shaft upon which was mounted a light wagon wheel, W, which served to hold the sweep off the ground. About 3 ft. from the end, A, was an eyebolt, I, to which was fastened an anchoring chain, C, anchored to a pile, or tree, or deadman, P. Near the end, B, was a single or double whiffletree to which one or two horses were hitched. On each side of the bolt I and about 4 ins. away were hook bolts, $h_1$ and $h_2$, and still farther out were similar hook bolts $h_3$ and $h_4$. A link of the pile pulling chain C was first hooked into a short chain $K^1$ and carried out and over an A-frame F and fastened to the pile to be pulled, as shown in Fig. 2. The other end of $K^1$ was hooked to $h^1$; now by driving the team in the direction of the arrow in Fig. 1, it is apparent that the chain C will be tightened. When the team has walked a short distance, however, it must be turned about and made to travel in the opposite direction, the sweep being in position shown by dotted lines at the time of reversing. Before starting the team on its reverse trip, a short length of chain shown by the dotted line K in Fig. 1 is hooked at one end to a link in chain C, and at the other end to hook bolt $h_3$ of the sweep. Thus it will be seen that when the team starts on its reverse trip the strain comes upon chain K, so that chain $K^1$ can be unhooked. Thus by reversing the team at each end of the arc of travel, and by alternately using the two short chains K and $K^1$ on the alternate hook bolts $h_3$ and $h_4$, it is evident that the slack must eventually be taken out of chain C, and finally an enormous pulling strain must come upon the pile p. If the distance from the whiffletree king-bolt to the bolt I is 20 ft., and if $h_1$ and $h_3$ are 4 ins. (= ⅓-ft.) from I, it is evident that the pull of the team is multiplied $3 \times 20 = 60$ times. A single horse capable of pulling 500 lbs. would thus develop a pull of $60 \times 500 = 30{,}000$ lbs. on one of the short chains K or $K^1$. If in the triangle a b c of Fig. 2, a b represents this 30,000-lb. pull, then a c represents the pull on the pile, which it will be seen is always greater than 30,000 lbs., depending upon the inclination given to the A-frame F. If the A-frame F has a batter of 1 in 3, the pull on the pile will be approximately $3 \times 30{,}000 = 90{,}000$ lbs. It will be noted that this is an enormous stress, and that very substantial wooden blocking must be placed under the A-frame to prevent its sinking into the ground. It will also be noted that no horse can maintain a 500-lb. pull very long, hence a team must be used where so great a pull is needed. It is not known just what stress was developed in the chain fastened to the pile, not only on account of the unknown power of the horses, but because of the roughness of the whole machine; ¾-in. rods 6 ft. long with a hook at one end and an eye at the other were used at first as long links for the chain C, but although strong enough for stump pulling they failed in pile pulling because the hook ends would straighten out. The hook ends were then bent farther over and welded to the rod, forming eyes, but when piles about 12 to 15 ft. in the ground were encountered this long link chain began to break and had to be given up.

Due to the expense of making or buying a heavier long chain C, and to the slowness of this method of pulling long piles, it was decided to make a new pile-pulling machine of a different type. In the light of after experience, however, it was questionable whether it would not have been best to use the machine just described, after providing it with heavier chains and fastenings. It is an exceedingly simple device as will be seen, with no expensive gearing liable to breakage. Once set up and anchored it will serve to pull a large number of piles, for it is only necessary to move the comparatively light A-frame F from pile to pile. The sweep itself can be placed on shore, or as in this case on an island in the river, and with long enough chain C can be used to pull piles several hundred feet away, although it is desirable on account of delay in gathering up the slack in the chain C at each new pile not to have any more than 50 or 75 ft. of chain to lift. The crew was 1 foreman, 3 laborers and 1 team with driver, with total wages amounting to $10 a day of 10 hours. This force with the sweep stump puller just described daily pulled 26 piles driven 5 to 6 ft. deep, including the pulling up the bottom of an old timber crib buried in the gravel around the piles. The best day's work in pulling these short piles was 40 piles. About 10 piles was a fair day's work when piles were 10 to 15 ft. deep in the ground. As showing the strain developed by a single horse it may be stated that a common link chain made of iron 1⅛ ins. diam. was broken by a straight steady pull. This chain was fastened to a pile that when pulled proved to have been 15 ft. in the ground. Such a chain ordinarily has a breaking strength of 60,000 lbs.

As before stated the expense of providing a long chain made of iron 1¼ to 1½ ins. diam. led to the abandonment of this sweep stump puller, and perhaps unwisely.

### A TRIPOD PILE PULLER.

This machine consisted of three 8 × 8-in. legs, 10 ft. long, with gearing mounted on two of those legs, as shown in Figs. 3 and 4. A 2½-in. manila rope was reeved through a set of triple sheave blocks fastened to the pile, and a set of double sheave blocks chained to the top of the tripod, the rope then passing to a small 4-in. cast-iron drum. Keyed to the same shaft with the drum was a 20-in. cog wheel meshing with a 4-in. pinion on a second shaft provided with turning cranks. This second shaft was also provided with a 12-in. drum from which a small hemp rope could be run to a 4-HP. engine. This arrangement of gear wheels, drums, and blocks, it will be seen, multiplied the power 270 times, so that a small 4-HP. engine was able to pull piles driven 27 ft. into the ground, although a great amount of power was consumed in friction of the gearing.

The blocks each had three 16-in. sheaves and were apparently unbreakable, yet several times they were torn to fragments under the strain. Breakage under such enormous strains is dangerous, for pieces of iron and wood fly with great velocity in all directions. It cost $100 to make two of these tripod pile pullers and about $300 more for rope, blocks, and repairs.

The crew for each puller was 3 laborers, 1 foreman, and 1 engineman and engine, making the daily force account about the same as with the sweep stump puller; that is, $10 a day, including 500 lbs. of coal. About 700 piles were pulled with these tripod machines, the average depth of pile being 12 ft., although many were 20 to 25 ft. deep. The best day's work was 25 piles pulled, and the average was 15 piles by each machine, making an average cost for labor 70 cts. per pile. It cost $100 for high-top rubber boots for the men, and $400 more for the machines, as above stated, making the cost per pile pulled 70 cts. for machinery plus 70 cts. for labor. The machines were of course of little value after work was finished, as they had been made for a special purpose.

In pulling the deepest pile—a huge oak one some 18 ins. across the butt and 27 ft. deep—the chain that passed around the pile and fastened to the blocks was broken several times. The links of this chain were of 1¼-in. iron, and such a chain has a breaking strength of 100,000 lbs.

As the weather grew colder breakage of this chain became more and more frequent, even with much shorter piles, showing conclusively how a low temperature affects the strength of iron. Finally, when freezing weather was reached, pile pulling was given up entirely, as the men could not stand working in the water.

### BLASTING OUT PILES.

Before pile pulling was begun, an attempt was made to blast out the piles by boring an auger hole 4 or 5 ft. deep down through the heart of the pile, and exploding three or four sticks of dynamite in the hole. The foreman had been instructed to use 70% dynamite, but finding none readily obtainable in the market he used 40% dynamite, and, as might have been foretold, the results were far from satisfactory, for the tough water-seasoned oak merely splintered into long whipcords. In a word, the dynamite did not cut the piles off at the bottom of the hole. The foreman reported that dynamite was a failure, and not till months afterward was it discovered that he had not obeyed instructions. When work was resumed in the spring of the year, 70% dynamite was tried and with most encouraging results, even at the first trial. After some experimenting it was found that two ½-lb. sticks of 70% dynamite, and one stick of 40% dynamite in each hole would cut the largest pile off and hurl the top 50 to 100 ft. up into the air.

Long ship augers making holes 1½ ins. in diameter were used, and holes were bored about 4½ ft. deep down the center of each pile. One man would bore 7 such holes per 10-hour day, at a cost of 21 cts. per pile for the boring; 1 lb. of 70% dynamite at 20 cts. a lb. and ½-lb. of 40% dynamite at 15 cts. a lb., made the cost of powder 28 cts. per pile. To this was added 5 ft. of fuse, 3 cts., and a cap, 1 ct., making a total of 55 cts. per pile for labor and explosives. The cost of loading and firing (water tamping was used) was a very small item as two men would load and fire 100 holes a day. Once in awhile a very tough pile would resist the dynamite, leaving a splintered snag. Pulling these snags added about 10 cts. to the cost of each pile blasted, which might have been avoided by using three sticks of 70% dynamite throughout in the first place. Finally there is to be added the cost of superintendence, which depends entirely upon the number of men engaged in boring.

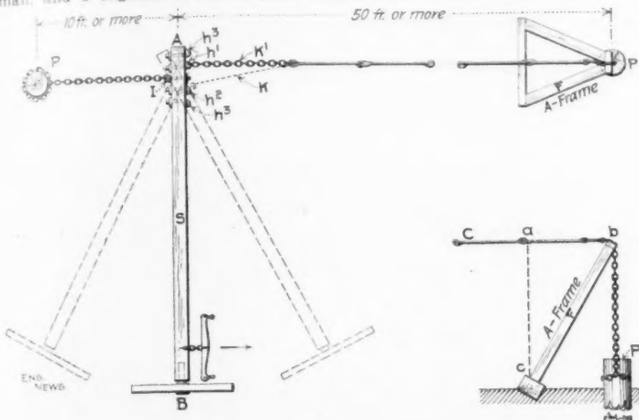



Fig. 1. Plan of Sweep Pile Puller.

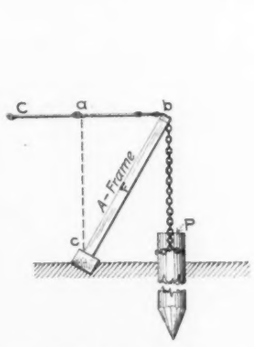



Fig. 2. Side View of A-Frame of Sweep Pile Puller.

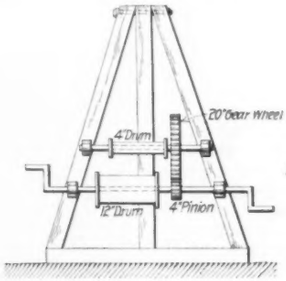



Fig. 3. Front View of Tripod Pile Puller.

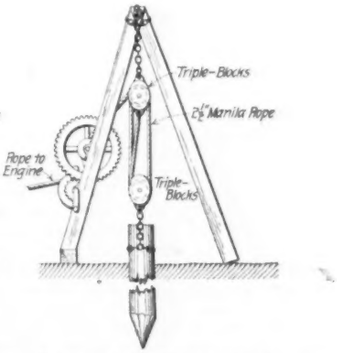



Fig. 4. Side View of Tripod Pile Puller.

### SUMMARY.

It will be seen that pile blasting is considerably cheaper than pulling where the piles are required to be removed only 4 or 5 ft. below water surface, that is, where the hole bored is only 4½ ft. deep.

As between the sweep machine and the tripod machine, if the job is a small one, by all means employ the sweep machine, as it costs less to make and has little about it requiring repairs. It is unquestionably slower than the tripod machine for piles over 10 ft. deep in hard ground; for even with several pairs of hook bolts, $h_1$, $h_2$, $h_3$, $h_4$, etc., Fig. 1, that would enable increasingly longer "bites" to be taken, there is more time consumed than in the direct winding of an engine on the drum of the tripod puller. The tripod machine could be provided with wagon wheels in place of the cranks, Fig. 4, and in that way moved readily from place to place. This would be especially desirable where it is to be used for pulling stumps.

There were several amusing incidents in connection with the work, among them being the frequent visits of committees of one or two farmers. These committees were all agreed that pile pulling differed in nowise from stump pulling, except that piles must surely be easier to pull. A dozen or so of these owners of "patent stump eradicators" were willing to sell their machines for a small consideration. Finally a crude sign was made and posted by the foreman. It read: "Stump-pulling and lightning-rod agents, please move on. This is our busy day."

## THE RAW MATERIALS EMPLOYED AND THE AMOUNT OF PORTLAND CEMENT MADE FROM EACH IN THE UNITED STATES.

By Edwin C. Eckel,* Assoc. Am. Soc. C. E.

No data are at present furnished, in either official or private publications on the mineral industries of the United States, for determining what portion of the total Portland cement production is made from any given set of materials. The writer has received frequent inquiries in regard to this point from cement manufacturers, machinery firms, and others interested in the development of the industry, and has in consequence prepared the following brief statement on the subject. It must be clearly understood that the figures here given are in no sense official, as the writer's work for the Geological Survey is in no way connected with the statistical branch of that organization. As to the accuracy of the figures, that is another matter. The writer believes that they may be accepted with entire confidence, as they are based upon very complete data, compiled and tabulated by himself, on the materials and methods at the various plants.

Though, theoretically, Portland cement could be made from an almost infinite number of combinations of various materials, economic considerations restrict the field of choice to such an extent that the materials actually in use may be tabulated under a few heads. At the present day all Portland cement in the United States is made from one of the following six combinations:

(1) At a few points a limestone is found low in magnesia and carrying silica and alumina in such proportions as to require the addition of a relatively small amount of pure limestone to make a good Portland cement mixture. Practically all the Portland cement produced in Pennsylvania, New Jersey, and the Virginias falls under this head.

(2) In the States of the North and the middle West, deposits of marl and clay occur abundantly. These are mixed to make a Portland cement mixture. These materials are easily excavated and readily reduced, but carry as excavated a large percentage of water, which increases the cost of handling and of transportation from marl bed to mill. The water also practically necessitates a wet mixture, which increases the fuel cost in burning.

(3) In certain southern and western states a soft chalklike limestone is used in combination with clay. This material is readily excavated and easily ground, having the advantage over marl in that it carries practically no water. Deposits of this character are common in some states, and will probably be the basis of an important industry.

(4) Hard limestones are used in combination with clay, the principal eastern representatives of this type being in New York. The writer has elsewhere* discussed these materials and described typical plants.

(5) Caustic lime, derived as a waste product in alkali manufacture, has been utilized at one plant

*U. S. Geological Survey, Washington, D. C.

*Engineering News, Vol. 45, pp. 365-367, 1901.

TABLE I.—Showing Production of Portland Cement from Various Materials.

| | Type 1. Argillaceous limestone and pure limestone | | Type 2.* Marl and clay. | | Type 3. Soft limestone and clay. | | Type 4.† Hard limestone and clay. | |
|---|---|---|---|---|---|---|---|---|
| | Barrels. | Total. | Barrels. | Total. | Barrels. | Tot'l. | Barrels. | Total. |
| 1898 production | 2,682,304 | 74.9% | 545,372 | 15.2% | 39,000 | 1.1% | 315,008 | 8.8% |
| 1899 " | 4,010,122 | 70.9% | 1,095,934 | 19.4% | 88,200 | 1.6% | 458,000 | 8.1% |
| 1900 " | 5,919,629 | 70.3% | 1,444,797 | 17.1% | 184,400 | 2.2% | 874,715 | 10.4% |
| 1901 " | 8,503,500 | 66.8% | 2,001,200 | 15.8% | 495,752 | 3.9% | 1,710,773 | 13.5% |
| 1902 " | 10,600,000 | 67.9% | 2,200,000 | 14.1% | 700,000 | 4.5% | 2,100,000 | 13.5% |

*Including also the product from alkali waste and clay, Type 5, at one plant.
†Including also the product from slag and limestone, Type 6, at two plants.

in Michigan, while another alkali plant is now carrying on experiments along the same line. The figures for this process have been included in the following table with those of type 2.

(6) Blast furnace slag is used in combination with limestone in the manufacture of a true Portland cement. Two plants now utilize this combination of materials and others are in prospect. The figures for this type are included with those of type 4.

In the preparation of the following table the writer has utilized the figures for total production of Portland cement given in the volumes of "Mineral Resources of the United States" for 1898, 1899, 1900 and 1901, respectively, corrected where necessary. The production given for 1902 is an estimate by the writer, and is probably too low rather than too high.

These totals have been distributed among the six classes, as distinguished by the materials used, according to the writer's knowledge of the materials utilized at the various plants. It is believed that this distribution is practically correct.

Examination of the foregoing table would seem to justify the conclusions that: (1) The proportion of the total output produced by the use of argillaceous limestone to the total production is slowly decreasing. The areas of good "cement rock" in Pennsylvania and New Jersey are limited; and some of the Pennsylvania companies are hard pushed to obtain the pure limestone which they require for addition to the "cement rock." (2) The production of cement from marl and clay, compared to the total, is also decreasing slowly. The marl cement plants of the middle west have been built too fast for their markets. (3) The product from a mixture of soft chalky limestone and clay is increasing quite rapidly. The plants using this mixture are located in areas where they have little competition, and will probably expand greatly within the next few years. (4) The plants using hard limestone and clay are slowly increasing their product, as compared with the total production.

The advance in the slag (puzzolan) cement industry during 1902 will be discussed by the writer in the forthcoming volume of the Mineral Industry (vol. XI). It is sufficient to state here that the production for 1902 was in the neighborhood of 800,000 barrels of 380 lbs. net, and that during 1903 it will probably reach the million barrel mark.

## THE MARLBOROUGH BROOK FILTER BEDS.

By Walter W. Patch.*

As an illustration of the application of the principles of slow sand filtration of water to a case presenting many unusual features, the following description of the construction and operation of the Marlborough Brook filter beds may be of interest. These filter beds (Fig. 1) were built during the season of 1899, for the Metropolitan

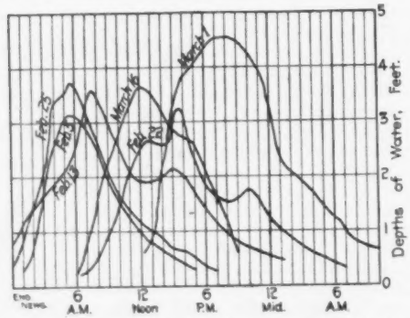



Fig. 2. Depth of Water Flowing Over Stop-Plank at Settling Reservoirs, Freshets of 1900.

Water-Works of Massachusetts, and received brief mention in Engineering News of Aug. 30, 1900.

The object of the filter beds, as stated in the article mentioned above, is to purify the waters of a brook draining a large part of the most thickly settled portion of the city of Marlborough; the latter having a population of about 14,000, and being directly adjacent to the northerly portion of the largest completed reservoir of the Metropolitan Water-Works system. Formerly many cases of gross pollution existed along the banks of this brook, but since the completion of the Marlborough sewer system in 1892, and the establishment of systematic sanitary inspection by the Metropolitan Water Board, most of the sources of direct contamination have been removed. During heavy rainfalls, however, nearly all of the street washings, and occasional contributions of sewage, are included in the runoff of the brook, which at such times, if not purified, would be a highly objectionable source of water supply.

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The drainage area of Marlborough Brook, above the filter beds, is about 1.8 square miles. It is composed largely of steep side hills from which the runoff is very rapid; the maximum discharge at the filter beds at times occurring within an hour or two of the greatest intensity of rainfall. The flashy nature of the drainage area is well illustrated by Fig. 2, which shows the depths in feet flowing over the 8-ft. stop planks at the filter bed settling reservoir during the spring freshets of 1900.

It will be noticed that even in the case of the freshet of March 1, which was the largest in 40 years, the flow was above the normal for less than 24 hours. The yields, in million gallons, at the filter beds, corresponding to the freshet flows plotted on Fig. 2, are shown graphically in Fig. 3.

The condition of yield required either a large storage reservoir, or a very liberal provision for filtering area; and the latter, although involving the greater annual charge for maintenance, seemed to be the best adapted to the local topography.

The accompanying plan, Fig. 4, shows the general arrangement of the beds, and of the distribution and drainage systems. The settling reservoir, north of the filter beds, was built in 1898; it has a depth of 6 ft. at high water, and a capacity of about 2,700,000 gallons. This reservoir serves to intercept the heavier sediment brought down by the brook, and as its bottom was carefully graded and rolled the removal of silt is readily accomplished. The settling reservoir has been cleansed twice in three years, and over 2,000 cu. yds. of sediment was removed in the two cleanings. In cleaning the mud is piled up in windrows and then loaded into carts.

The diverting weir, at the head of the supply and waste channels, was designed to pass to the main supply channel all the water that the beds could safely handle, and to waste the excess through a paved channel directly into the Sudbury reservoir.

The formation on the site of Beds 1 to 16 was a nearly water-tight cemented gravel, covered with several feet of soil and loam. These beds were built almost entirely in excavation, in a series of terraces at six different elevations, and were filled with washed gravel and sand as hereinafter described.

The area covered by Beds 19 to 26 was formerly occupied by a group of gravelly knolls. This territory was prospected very thoroughly in 1898, both by open test pits and by about 100 wash drill borings, in order to determine whether the deeper gravel deposits were such as to allow the free passage of ground water through them. Many of the wash borings were carried from 20 to 30 ft. below high water in Sudbury Reservoir, and the casing of twelve of these deeper ones was left in place and daily observations on ground water elevation were made during a period of six months, while Sudbury reservoir was being filled from a point about 15 ft. below high water. The results were very interesting, and demonstrated beyond a doubt that the formation for many feet below the level of saturation was a free draining material.

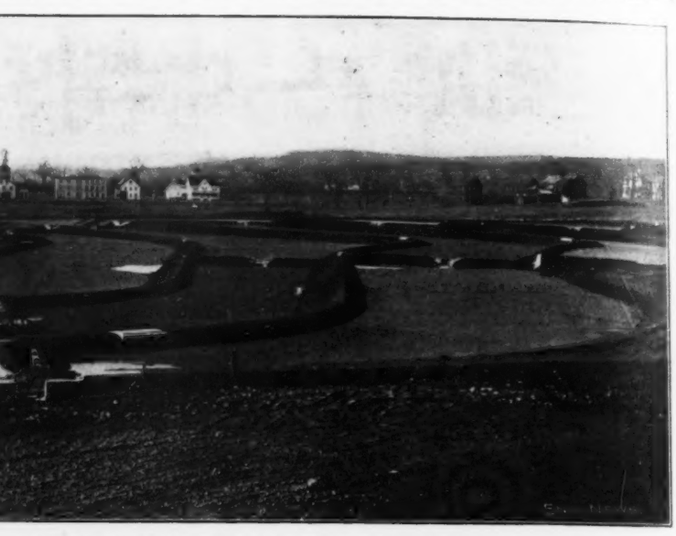


FIG. 1. VIEW OF A PORTION OF MARLBORO BROOK FILTER BEDS.
(Showing Beds 2 to 6, 9 to 12, 14, 15, and 17.)

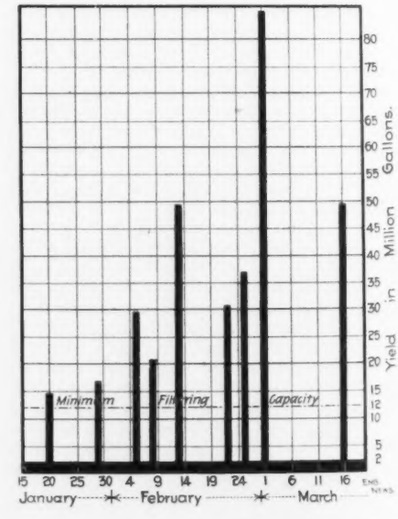



Fig. 3. Yields of Marlboro Brook Filter Beds During Spring Freshets of 1900.
Average winter yield, omitting freshets, about 2,000,000 gallons per day.

The surface of Beds 19 to 26 is, in general, 11 ft. above high water in Sudbury reservoir. These beds were constructed largely in excavation, but contain some gravel filling around the edges. Their embankments were built of soil and loam, deposited in layers and rolled. The surplus sand and gravel from the site of Beds 19 to 26, to the extent of about 25,000 cu. yds., was used for the

filtering materials in Beds 1 to 17, most of it having first been screened and washed.

Beds 18, 27 and 28 comprise areas which were too low to be economically filled, hence they were surrounded by embankments, and are used at times to store surplus water. No. 18 can be filled 6 ft. in depth, and the other two will each

Fig. 4. Plan of Marlboro Brook Settling Reservoir and Filter Beds.

hold about 11 ft. of water. They have a combined capacity of about 7,500,000 gallons and generally require from one to two weeks to drain.

The filtration system includes about 115 masonry structures, concrete being used wherever practicable; and two miles of 6 to 24-in. drain pipes, with three different forms of joints.

In constructing the filter beds the first step was to excavate to the required depth the area to be occupied by Beds 1 to 17, depositing the loam and subsoil in embankments. Later, while the soil was being stripped from the site of Beds 18 to 26, the underdrains and masonry structures were under way for Beds 1 to 17, and a mechanical screening and sand washing plant was being erected on the site of Bed No. 21.

The specifications required that the filling for Beds 1 to 17 should be placed as shown in Fig. 4, and should consist of five sizes designated a, $a_1$, b, c, and d. The filter sand (a) was clean sand passing a screen having a clear opening of 5-16-in., and containing not more than 2% by weight of particles passing through a seive with openings 0.12-mm. diameter. Size $a_1$ was material passing through the lower 4 ft. of the 12-ft. sand screen, and was washed in the same manner as the sand in order to free it from dust and loam. Size b consisted of gravel stones caught on the 5-16-in. screen and passing through a screen having ½-in. holes. Size c was caught on the ½-in. screen and passed through a screen having 1½-in. holes. Size d consisted of tailings from the 1½-in. screen, from which stones more than 4½ ins. in diameter were removed by hand as the material was loaded into carts. Sizes b, c, and d, were washed by a jet from a 2-in. hose, while being loaded into carts. By this method of washing most of the dust is separated from the stones and was either carried from the rear end of the cart by escaping water, or, settling to the bottom as adhesive mud, was scraped from the cart body after the stones were dumped.

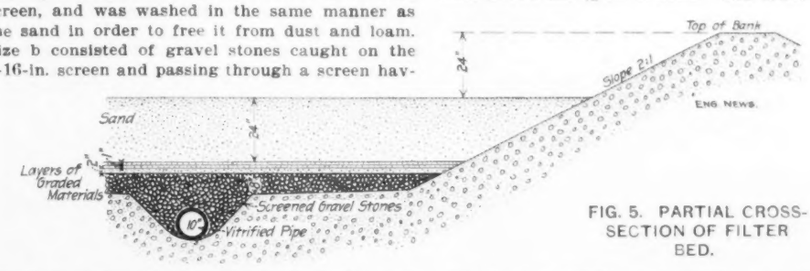



FIG. 5. PARTIAL CROSS-SECTION OF FILTER BED.

The screening and sand washing plant is shown diagrammatically by Fig. 6. It consisted of a raised dumping platform from which bank gravel could be fed into the upper of two revolving screens, each 32 ins. diameter. The sand dropped from the upper screen into a washing tank supplied from an 8-in. water pipe leading from the settling reservoir. The tailings from the first screen were separated by the lower screen into sizes b, c, and d, each of which entered its respective bin. The dirty water, resulting from the sand and gravel washing, was conveyed to the low area on the site of Bed 28, where it usually stood about 5 ft. deep, and from whence the water filtered through the ground, and was largely caught by the collecting drains beneath the surrounding embankments.

The screening and washing plant was constructed in duplicate, and either half could be operated independently of the other. The motive power originally constructed, was covered with steel wire cloth having 5-16-in. square openings; but as the work progressed, it was found that an insufficient supply of size $a_1$ was produced, as nearly all the material that would pass through the screen was separated in the first 8 ft. In order to remedy this difficulty, and at the same time to increase the supply of size b, the wire from the lower 4 ft. of sand screen was replaced by cloth of ⅜-in. mesh, and the product from this section was diverted into the bin for size b, and size $a_1$ was taken from the 2-ft. section of the 5-16-in. screen next above the ⅜-in. section. The lower screen was 8 ft. in length, and consisted of two 4-ft. sections of punched steel plate, having holes of ½ and 1½ ins. diameter, respectively.

During the first half-day following a hard rain, the sand screen could not be operated; but at other times, unless the gravel was unusually damp, operations could be continued by having a water-boy strike the screen with a club at every quarter turn.

The gravel used for screening was quite coarse. Mechanical analyses from test pits indicated that about 50% of the gravel would pass a 5-16-in. mesh screen, while about 30% consisted of stones larger than 2½ ins. in diameter. The proportion of sand contained in the gravel was found to be approximately as indicated, but as there was a frequent shortage on sizes $a_1$ and b, the thickness of these layers was reduced from 1 in. each, as shown on the contract plan, to ½-in. each. Some concern was felt lest these thin layers might in places fail to support the overlying materials; but great care was taken to keep them intact during construction, and in the three years the beds have been in use no sign of failure has been detected. The method of placing the screened materials is shown in Fig. 9.

The sand-washing apparatus, as shown by Figs. 7 and 8, was designed by the writer, following a suggestion offered by Mr. W. A. Tucker, mining engineer and ore-dressing expert. It consisted of a cypress tank of V-section, 13 ft. long, placed beneath each sand screen. The tank in section was 40 ins. wide at the top, 4 ins. wide at the bottom, and 45 ins. high. One side was cut down and provided with an iron crest ¼-in. wide, extending the entire length of the tank, and designed to keep the water 30 ins. deep. Water was supplied through six 1-in. pipes entering the tank horizontally at a distance of 12 ins. above the bottom. These supply pipes were furnished with quick-closing lever valves, and opposite the

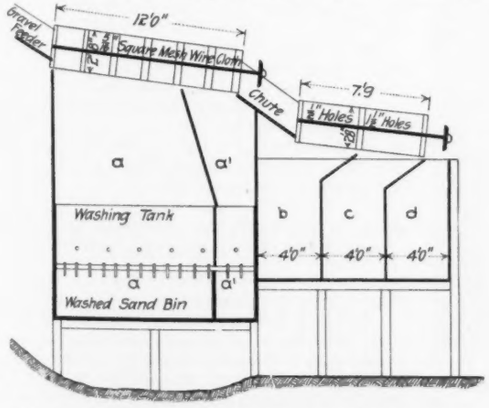



Fig. 6. Sketch Showing Arrangement of Sand Screening and Washing Plant.

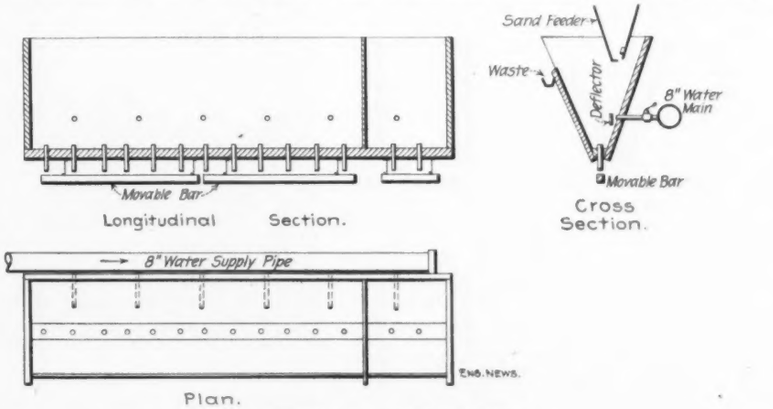



FIG. 7. DETAILS OF SAND WASHER.

end of each was a vertical deflector which developed two fan-shaped jets, the larger going towards the surface and the smaller towards the bottom of the tank. The sand as screened was fed into the tank at the water surface from a hopper extending its entire length and discharging sand at a very slight velocity directly over the fan-shaped jets. As the sand descended against the upward current of water the finer particles were separated and carried over into the waste trough. The bottom of the tank was

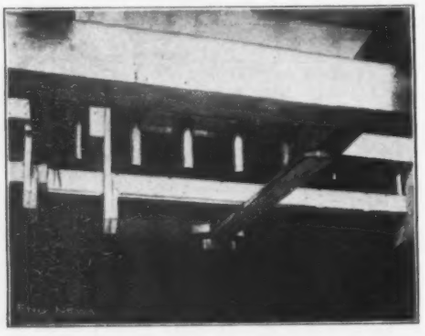


Fig. 8. View of Sand Washer Effluent Pipes and Controlling Device.

furnished with 14 effluent pipes, each 10 ins. long, projecting 1 in. into the tank. Commencing at that end of the tank beneath the upper end of the sand screen the first six effluent pipes were of 1¼ ins. diameter, and the last eight 1½ ins. in diameter.

This increase in the size of effluent pipes was occasioned by the coarser product derived from the lower end of the sand screen. The discharge of sand was controlled by a piece of 2 × 3-in. joist, suspended on stout hooks, so that it hung about 1½ ins. directly below the pipes. By means of a horizontal lever, shown in Fig. 8, the suspended joist could be brought instantly against the ends of the effluent pipes, or could be lowered at will. The proper diameter for the outlet pipes was determined only after repeated trials and failures. The bottom of the tank was designed with a row of 3-in. wooden plugs, 8 ins. c. to c., which were in turn fitted with all sizes of iron pipe from ½ to 1½ ins. diameter.

Two men were required to operate a sand washer, one controlling the lever which regulated the discharge; and the other distributing the sand evenly along the tank, as owing to the irregular rate of feed there was a tendency for the sand to pile up at different places in the tank.

Mechanical analyses of the sand entering the tank and of the washed product were made at frequent intervals each day. The washed sand very uniformly contained about 1.5% finer than 0.12 mm., and seldom equaled or exceeded the contract limit of 2%, while the unwashed sand was quite variable, but averaged about 5% finer than 0.12 mm.

About 11,000 cu. yds. of sand passed through the sand washers at an average rate per tank of 9 cu. yds. per hour, requiring approximately 2,000 gallons of water per cubic yard of sand. In washing sizes b, c, and d, by water from a hose, about 200 gallons per cubic yard was used.

Toward the end of the season, at a time when work was far behind the contract requirements, an extensive deposit of natural sand was uncovered. This sand was not of uniform-sized grain, nor did it meet the requirement that not over 2% should pass a seive of 0.12 mm. mesh; but in order to hasten the completion of the work, it was used for filter sand in several of the beds without any preliminary screening or washing. The "effective size" of this natural sand would average about 0.18 mm., while the average "effective size" of the washed sand was 0.24 mm., and the uniformity coefficient about five.

Beds containing the unwashed sand have proved much less efficient than the others. The rate of filtration is slower, they support a more active growth of weeds in summer, and freeze solid to a greater depth in winter. The last-mentioned difficulty is the most serious one, as owing to the protracted periods of slight yield which characterize this drainage area, it is possible to keep but one or two beds continuously flooded, and during the winter the surface of the others freezes to a greater or less extent. With the advent of a freshet, water is turned into all the beds, and in general those containing washed sand will commence to operate in a comparatively short time, while beds constructed with unwashed sand will remain sealed by frost until the need for their service has passed.

Beds 19 to 26, as before noted, contain natural gravel to a depth of 30 ft. or more. They are not underdrained in the strict sense of that term, but are surrounded by lines of vitrified pipes of large sizes, placed outside the embankments at about the level of high water in Sudbury reservoir. The pipes are laid with "filter joints," so-called, which are shown in section by Fig. 9, and in process of construction by Fig. 10. The vertical sheets of galvanized iron shown in the view were used to separate the side layers of screened materials, and were withdrawn before placing the covering layers. The filtering materials are continuous throughout the length of the trench.

The above method of protecting the pipes from being filled by sand is easy of construction, and has been entirely successful. Owing to delays in constructing the screening and washing plant a large proportion of the "filter joint" pipe was laid, using materials screened and washed by hand at a cost of about $1.25 per cu. yd.

The contract price of screened and washed sand and gravel was 60 cts. per cu. yd., which was about the actual cost of this material if cost of screening plant be deducted. The contract prices per foot for furnishing and laying pipes with filter joints were as follows: 10-in. pipe, 42 cts.; 12-in., 50 cts.; 15-in., 60 cts.; 18-in., 80 cts.; and 20-in., $1.25. Trenching was paid for as earth excavation, and filtering materials around pipes at the rate of 60 cts. per cu. yd. These prices for filter joint pipe represent very closely the actual cost to the contractor.

The details of maintenance and operation of the filter beds are somewhat complicated, owing to the fact that the rate of discharge of the influent brook varies from zero during short periods in the summer, to a maximum in the spring of 100,000,000, or even 150,000,000 gallons per day; while the applied water, notwithstanding the separation of from 600 to 800 cu. yds. of mud annually at the settling reservoir, may change in an hour from a crystal transparency to the color of chocolate.

Fig. 10. Effluent Collecting Pipe Under Construction.

Storage Beds 18, 27 and 28 have proved to be of great value in an emergency, as each, when empty, can take water at the rate of 20,000,000 gallons per day for a period of three hours, which will generally include the time of maximum freshet flow.

The beds are scraped during the early part of the summer, and are weeded once or twice later in the season. It is intended eventually to wash the dirty sand scraped from the sand filter beds, but it has not yet been found necessary to do so. The surface of the gravel filter beds is thoroughly harrowed after the scraping, and the loose stones have been found very useful for facing the embankments as a protection against wave action.

During severe winter weather, after a bed has been allowed to drain, it is not uncommon for the ice sheet to freeze fast to the surface of the sand and effectually seal the bed until spring. In order to overcome this difficulty it was thought that field stones about 6 ins. in diameter placed at in-

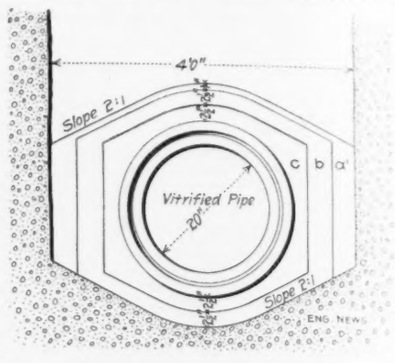



Fig. 9. Section Through Joint of Effluent Collecting Pipe and Surroundino Coarse Filtering Material.

a = coarse portion of material passing a 5/16-in. screen. b = 5/16 to ½-in. screened gravel. c = ½ to 1½-in. screened gravel.

tervals of 4 ft. over the entire bed, might support the ice clear from the sand. In practice, however, it was found that the heat of the sun and the weight of the ice would cause the latter to settle past the stones; hence they were of no effect.

Analyses of the influent and effluent waters have been made by the Massachusetts State Board of Health; but these perhaps do not fairly indicate the results obtained, as samples of influent water are rarely collected during freshet flows; and in collecting the effluent it is not possible to exclude all of the ground water, as the latter is always present in the underdrains even when the tributary beds are not in use. The appended table shows the average of weekly analyses made during the year 1900:

(Parts per 100,000.)

| Samples. | | | Influent brook water. | Effluent from filter beds |
|---|---|---|---|---|
| Color | Nessler standard | | 0.48 | 0.03 |
| | Platinum standard | | .45 | .06 |
| Residue on evaporation | Total | | 17.72 | 11.29 |
| | Loss on ignition | | 4.50 | .... |
| Ammonia | Free | | .1010 | .0096 |
| | Albumenoid. | Total | .0553 | .0071 |
| | | Dissolved | .0360 | ... |
| | | Suspended | .0193 | ... |
| Chlorine | | | 2.02 | 1.48 |
| Nitrogen as | Nitrates | | .1463 | .1828 |
| | Nitrites | | .0046 | .0005 |
| Oxygen consumed | | | .76 | .10 |
| Hardness | | | 5.7 | 4.1 |

Mr. Frederic P. Stearns, M. Am. Soc. C. E., is Chief Engineer of the Metropolitan Water and Sewerage Board, and Mr. Desmond FitzGerald, M. Am. Soc. C. E., was until recently Engineer of the Sudbury Department, and Mr. E. T. Larned was Principal Assistant Engineer. The writer was in charge of preliminary work, and was Resident Engineer during construction.

## COMPARATIVE TESTS OF LIMESTONE AND GRAVEL SCREENINGS AND TORPEDO SAND FOR CONCRETE.

By G. J. Griesenauer.*

In reading the above heading of this article the thought will no doubt occur to many that the relative positions of the two materials mentioned (screenings and sand) should be reversed, limestone screenings being generally carefully separated from the crushed stone used in concrete work, and being discarded as material of inferior value to clean, sharp torpedo or pit sand. Comparative tests made in the cement testing laboratory of the Bridge and Building Department of the Chicago, Milwaukee & St. Paul Ry., under the direction of Mr. C. F. Loweth, M. Am. Soc. C. E., Engineer and Superintendent, indicate, however, that limestone screenings are superior

*Cement tester, Chicago, Milwaukee & St. Paul Ry., Chicago, Ill.

TABLE I.—Comparative Strengths of Mortars made of Portland Cement and Pit Sand, and of Portland Cement and Sized Limestone Screenings.

| Material. | Proportions by volume. Cement. | Screenings or sand. | Size or No. of screenings or sand. | Tensile strength in lbs. per sq. in. Days. 7. | 28. | Months. 3. | 6. | 1 year. | Limestone screenings superior to Hammond sand, 1 to 3, in percentage. Days. 7. | 28. | Months. 3. | 6. | 1 year. | Average p.ct. limestone screenings superior to Hammond sand. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lannon screenings ... | 1 | 3 | 12—40* | 241 | 331 | 430 | 561 | 738 | 65.1 | 52.5 | 39.7 | 116.6 | 78.3 | 69.4 |
| Richwood screenings .. | 1 | 3 | 12—40* | 259 | 348 | 478 | 600 | 697 | 77.3 | 60.4 | 54.2 | 131.7 | 68.4 | 78.5 |
| Hammond sand ..... | 1 | 3 | 8 | 146 | 217 | 310 | 259 | 414 | .... | .... | .... | .... | .... | .... |
| Atlas cement ..... | | Neat. | .. | 652 | 761 | 723 | 723 | 690 | .... | .... | .... | .... | .... | .... |

*12—40 means that the screenings used passed through a No. 12 sieve and were held on a No. 40 sieve. Lannon screenings: 26.3% of what passed through the No. 12 sieve remained on the No. 40 sieve; 51.9% passed through the No. 40 sieve. Richwood screenings: 40.4% of what passed through the No. 12 sieve remained on the No. 40 sieve; 43.9% passed through the No. 40 sieve.

to either torpedo or pit sand. While the number of tests is somewhat limited, the results obtained are so uniformly and so decidedly in favor of screenings that they deserve attention and consideration.

The first and second series of these tests were started a year ago, and that portion of the screenings which passed through a No. 12 sieve and was held on a No. 40 sieve was used, the remainder being rejected. The results of this series are shown in Table I. Since that time other tests have been made, but using all the screenings which passed a certain sieve instead of rejecting the fine portion. The superiority of the whole screenings (all the material that passed a given sieve) over the sized screenings, is shown by a comparison of Tables I. and II. These tables also demonstrate the superiority of both classes of screenings to torpedo sand in tests made with the same cement and the same proportions of mixture.

As the tests were distributed over a period of more than a year, a different lot of cement was used for almost every series of tests, but in each case the cement selected was of either "Atlas" or the "Peerless" brand. The sand used was pit sand from the Hammond, Ill., pit, this sand having shown the best results of any pit, beach or river sand that has been tested in this laboratory. The crushed limestone was from the quarries indicated in the tables.

Table I. shows tests of Lannon and Richwood crushed limestone screenings. This material is composed of screenings that passed a No. 12 sieve and were held on a No. 40 sieve. These tests average about 74% better than the comparative sand tests, and at the age of one year nearly 4% better than the neat tests. Both of these results are remarkable. Table II. shows tests of Dolese & Shepard crushed limestone screenings. The screenings used in all but one of these tests represent everything passing through sieves as indicated. These tests show that it is desirable to use the whole of the screenings. The 1 cement to 3 screenings mortars average about 115% better than the 1 to 3 sand mortar. Even the 1 to 6 screenings mortars show an average of 22.9% greater strength than the 1 to 3 sand mortars. The 1 to 3 No. 4 screenings are about 23% better than the 1 to 3 No. 8 screenings. This table contains many remarkable comparisons, and warrants considerable study. Table III. shows tests of crushed limestone and crushed gravel screenings. These tests confirm the conclusions reached from Tables I. and II. and emphasize the superior strength of limestone screenings over sand. Note in this table the great difference in the figures for limestone screenings and crushed gravel, and the slight difference in the figures for crushed gravel and sand. This table represents a rather limited number of tests. It cannot be considered as absolutely convincing, but is suggestive enough to have a bearing on the subject.

These tests are suggestive in view of the thousands of carloads of limestone screenings that are separated from the crushed stone at the crusher mills and piled up as rejected waste, supposed to be valueless material. They also contradict reported tests of the inferior value of stone dust and screenings as compared to torpedo sand in concrete. In fact they indicate value in limestone screenings over torpedo or pit sand such as was never dreamed of. Are not these tests, showing over 100% in favor of limestone screenings over pit sand, worthy of serious consideration?

As stated, the tests are limited in number, about 225 tests in all being included in the three tables. The great and uniform strength of the mixture made with limestone screenings as compared with the other mixtures surely has some bearing on the greater value of the screenings. After the briquettes of the different compositions were tested for tensile strength, they were subjected to the steam and boiling tests and proved entirely satisfactory. These tests are preliminary, and other tests are under way.

As shown in the tables, the proportions of the different mixtures were determined by volume and not by weight. The volume method for determining proportions of the mixtures is preferred by the writer for the reason that the different relative weights of different limestone, sands and cements (which difference may vary greatly) would change the intended proportions, and also for the reason that in regular concrete work the proportions are nearly always determined by the volume method.

The sand used should be clean: i. e., free (or nearly so) from loam or clay and should be naturally clean rather than washed sand, because in washing some of the very fine particles (a valuable part) are almost sure to be lost, unless special care is taken. The sand used in the accompanying tables contains less than 1% of substances soluble in water.

The theory of the writer as to the cause of limestone screenings being superior to sand or crushed gravel, is briefly this: (1) The limestone is porous as compared to sand or gravel, therefore there is the possibility of its becoming saturated with the fluid mixture of cement and water. The smaller the particles of stone, the more completely saturated will they become. This suggests a tendency of the mixture to become homogeneous in composition and simultaneously homogeneous in strength to a greater degree than is possible for a sand or other less porous material similarly mixed. (2) The elements contained in limestone are solid-forming or crystallizing elements. When these elements are attacked by the active crystallizing and solid forming elements of the cement, they form a chemical union with the cement. The more complete the saturation, the more complete will be the union: thus the limestone and the cement form an intermingled homogeneous mass. (3) A mixture of cement and limestone screenings packs very closely, the particles being such as to fit themselves closely to one another, thus reducing the voids.

To establish more closely and more firmly the exact value of the screenings of crushed limestone, and in what proportion this material should be used in concrete to give the best results, elaborate and careful comparative tests should be made by those interested in this line of work.

TABLE II.—Comparative Strengths of Mortars made of Portland Cement and Pit Sand, and Portland Cement and Limestone Screenings.

| Material. | Proportions by volume. Cement. | Screenings or sand. | Size or No. of screenings or sand. | Tensile strength in lbs. per sq. in., at Days. 7. | 28. | Months. 3. | 6. | 12. | Limestone screenings superior to 1 : 3 Hammond sand, in percentage, at Days. 7. | 28. | Months. 3. | 6. | 12. | Average per cent. limestone screenings superior to 1:3 Hammond sand. | Per cent. limestone screenings or Hammond sand passing the different sieves. Sieve No. | Percentage Limestone screenings. | Hammond sand. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. & S. screenings .... | 1 | 1 | 8 | 479 | 699 | 805 | 862 | 846 | 201.3 | 209.3 | 213.2 | 139.4 | 150.3 | 182.7 | 4 | 96.9 | 100.0 |
| " " ... | 1 | 2 | 8 | 373 | 544 | 726 | 796 | 804 | 134.6 | 142.0 | 182.5 | 121.1 | 135.0 | 143.0 | 8 | 75.9 | 76.8 |
| " " ... | 1 | 3 | 8 | 313 | 453 | 557 | 685 | 755 | 96.8 | 100.4 | 116.7 | 90.3 | 123.4 | 105.6 | 12 | 59.5 | 66.1 |
| " " .... | 1 | 4 | 8 | 261 | 348 | 475 | 628 | 664 | 64.2 | 54.0 | 84.8 | 77.5 | 96.2 | 75.3 | 24 | 30.4 | 41.2 |
| " " .... | 1 | 5 | 8 | 183 | 304 | 433 | 563 | 598 | 15.1 | 30.1 | 68.5 | 55.5 | 76.9 | 49.2 | 50 | 16.1 | 8.6 |
| " " .... | 1 | 6 | 8 | 151 | 255 | 336 | 453 | 475 | 0.6 | 12.8 | 30.7 | 25.8 | 40.9 | 22.2 | 100 | 10.6 | 1.9 |
| " " .... | 1 | 3 | 4 | 357 | 531 | 598 | 745 | 848 | 124.5 | 133.2 | 132.7 | 106.9 | 150.9 | 129.6 | 200 | 7.04 | 1.1 |
| " " .... | 1 | 3 | 4—8* | 193 | 247 | 247 | 300 | 386 | 21.4 | 10.2 | —3.8 | —16.7 | 28.7 | 8.0 | ... | .... | .... |
| Hammond sand ..... | 1 | 3 | 8 | 159 | 226 | 257 | 360 | 338 | ..... | ..... | ..... | ..... | ..... | ..... | ... | .... | .... |
| Atlas cement ..... | | Neat. | .. | 710 | 748 | 680 | 756 | 825 | ..... | ..... | ..... | ..... | ..... | ..... | ... | .... | .... |

*4—8 means that the screenings used passed through a No. 4 sieve and were held on a No. 8 sieve.

TABLE III.—Comparative Strength of Mortars made of Portland Cement and Pit Sand; Portland Cement and Crushed Gravel Screenings, and Portland Cement and Limestone Screenings.

| Material. | Proportions of volume. Cement. | Screenings or sand. | Size or No. of screenings or sand. | Tensile strength in lbs. per sq. in. at Days. 7. | 28. | Screenings superior to Hammond sand in per ct., at Days. 7. | 28. | Average per cent. screenings superior to Hammond sand. | Percentage of gravel screenings passing the different sieves. Sieve Nos. 4. | 8. | 12. | 24. | 50. | 100. | 200. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. & S. screenings ..... | 1 | 3 | 8 | 429 | 558 | 107.3 | 66.6 | 87.0 | 100.0 | 64.8 | 51.2 | 28.8 | 16.0 | 10.6 | 7.5 |
| Gravel screenings ..... | 1 | 3 | 8 | 299 | 340 | 1.0 | 1.5 | 1.3 | .... | .... | .... | .... | .... | .... | ... |
| Hammond sand ..... | 1 | 3 | 8 | 207 | 335 | .... | .... | .... | .... | .... | .... | .... | .... | .... | ... |
| Peerless cement ..... | | Neat. | .. | 811 | 975 | .... | .... | .... | .... | .... | .... | .... | .... | .... | ... |

Remarks.—The Dolese & Shepard crushed limestone screenings used is the same material as that in Table II.

## THE NEW SEPTIC TANKS AND BACTERIAL CONTACT BEDS AT EXETER, ENGLAND.

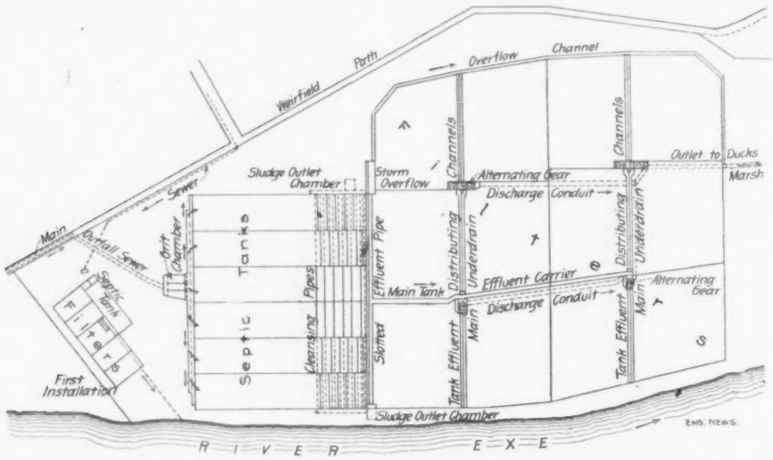
New septic tanks and bacterial filter beds were formally opened at Exeter, England, on Aug. 13, 1902. This disposal plant is designed to treat the sewage of the whole city, succeeding the preliminary plant serving some 1,500 people which was put in operation six years earlier, on Aug. 16, 1896, and described at length in Engineering News of Jan. 13, 1898. The smaller plant, or rather a still smaller one that preceded it by a few months, was the pioneer, at least in Great Britain, of modern attempts to take advantage, in a scientific manner, of the long-known, yet unknown, processes by means of which the organic matter in water-borne sewage mysteriously disappears from cesspools. The Exeter experiments, and the design of the new works there, fall to the credit of Mr. Donald Cameron, City Surveyor of Exeter. The following description of the works is reprinted, with slight condensation, from the London "Surveyor:"

These works are designed to serve a population of 47,000, the maximum flow of sewage and storm water provided for being 3,000,000 (U. S.) gallons per day. They consist of three grit chambers, six septic tanks, and 12 aerating bacterial filters, all of which are built in concrete. The main outfall sewer discharges into the grit chambers, which are each 18 ft. long by 6 ft. in average width by 3 ft. deep. From these chambers two channels lead off to the septic tanks, into each of which the sewage will be delivered by four submerged inlets. Each of the six tanks is 180 × 36 ft., × 8½ ft. deep below the springing, and is covered with a series of concrete arches over which a layer of soil is spread. Access to each tank is provided by means of two manholes, with sealing covers.

The effluent, freed from solids in suspension, will pass off through slotted cast-iron pipes, laid horizontally across the ends of the tanks, 3½ ft. below the springing, into the

effluent collecting channel. The inlets and outlets to the tanks will be controlled by independent valves, so that any one of them can be thrown out of use without interrupting the flow through the others.

The smaller tank, which has dealt with the sewage of St. Leonards since 1896, was in use continuously for five years before it became necessary to remove any deposit therefrom. It is, therefore, not expected that the deposit in the new tanks will need to be removed, except at very long intervals. In order that this may be done when necessary without draining off the liquid contents of the tanks, a series of V-shaped grooves and slotted pipes are constructed across the end of each (see accompanying




PLAN OF SEPTIC TANKS AND CONTACT FILTER BEDS, EXETER, ENGLAND.
(The small septic tank and filter beds at the left form the preliminary plant opened in 1896.)

plan.—Ed.) from which 6-in. cleansing pipes are led off to the cleansing chambers. By opening a valve in the latter, the deposit from the end of any tank may be drawn off and dug into the ground. The effluent channel is 2 ft. wide, and runs across the ends of the tanks. The tank effluent will pass therefrom by the main effluent carrier to the admission valve chambers of the filters.

An overflow weir with a flight of aerating steps is placed at the northeast corner of the septic tank, in case the flow should at any time exceed the maximum for which the filters are designed. The low-water level in the tanks is about 2 ft. below the weir crest, the intermediate space affording a reserve capacity to receive the first rush of storm water. The whole flow of the sewer in storm time will thus be dealt with by the septic tanks, and storm water and sewage up to nearly three times the dry-weather flow will also be treated in the filters before any overflow can take place. Each of the 12 filters is about 1,000 sq. yds. in extent, their total area being 2½ acres. They are filled to a depth of 3½ ft., with furnace clinker, broken to pass through a ½-in. screen, and freed of dust. The tank effluent will be distributed over each filter in turn by eleven lines of stoneware channels, laid on the top of the filtering material and fed by a concrete main distributor. The filtered effluent will be collected by lines of 3 and 4-in. agricultural drain pipes, laid on the filter floor and discharging into a main collector formed in concrete under the distributor. The main collector runs into a cast-iron discharge well in the bottom of which the discharge valve is placed.

The filters are arranged in groups of four, each group being arranged around a central gear chamber. For the group next the river two chambers are provided. Two of the three groups will ordinarily form the working set, and the tank effluent will be delivered to each filter in turn through its admission valve. The discharge valve will be closed meanwhile, so that the interstices of the filtering material will be filled with the tank effluent. The effluent will remain in the filter for an hour and a half, during which the impurities present in solution will be oxidized by the bacteria attached to the surfaces of the filtering medium. The discharge valve will then be opened, when the filtered effluent will escape, drawing down after it a supply of air into every crevice of the filter. The latter will then drain and aerate while the remaining filters of the set are filling, after which it will be again filled. The spare group should be thrown into work in the place of one of the others every few days, so that each group in turn may have a regular interval of complete rest.

The filling and emptying of the filters will be effected automaticaly by means of the alternating gear, consisting for each filter of levers from which the admission and discharge valves are suspended. The discharge valve lever has an actuating bucket at one end and a counterweight at the other, and the admission valve is opened by a weighted float. As soon as a filter is filled, a small quantity of filtered effluent will overflow from its discharge well into the float chamber, raising the float and closing the admission valve. A further overflow will take place through a regulating orifice into the actuating bucket whereby, after the proper interval has elapsed, the discharge valve will be opened and the contents of the filter released. The discharge of the full filter will bring about the emptying of the actuating bucket of the next filter, the counterweight of which will then come into play, closing its discharge valve, and opening the draining valve of the float chamber, the contents of which will then escape, thus bringing about the opening of the admission valve. The flow of tank effluent to a group of filters will be stopped during the whole time that a filter remains full, so that by the time the admission valve of the next filter is opened a large quantity of tank effluent will have accumulated, which will quickly fill the filter. In order that this cycle may go on continuously without outside help, the overflow pipes from all the filters in a group are connected into a continuous ring, a four-way cock being placed at every junction. The cutting out or throwing in of a filter is effected by merely giving this cock a quarter turn. The smaller installation already referred to has been at work for the past six years, the only regular attention it has required having been the periodical throwing in of the spare filter in the place of one of the others, oiling the bearings every few weeks, and loosening the surface of the filters at longer intervals when these have become compacted.

In accordance with the undertaking given to the local government board, the filtered effluent is conveyed by a 3-ft. discharge main to Ducks Marsh, which was acquired by the council many years ago for the purpose of sewage disposal. The outlet sewer ends in a manhole, from which four contour carriers convey the filtrate to the different levels of the marsh.

The work of the contractors, Messrs. Cooke & Co., of Westminster, was commenced in April, 1900, and completed in January of the present year (1902). The excavations amounted to 32,000 cu. yds. About 7,500 cu. yds. of cement concrete was used in the construction of the works, and eight miles of collecting drains and two miles of distributing channel laid, while the filters were filled with 17,000 cu. yds. of filtering material, composed of crushed and screened clinkers. The money borrowed to defray the cost of the whole scheme, including land, tanks, and filters, was $204,500. Of this amount, Messrs. Cooke's contract absorbed $62,400, and the filter material $10,200.

## A TRUCK SUPPORT FOR FURNACE BOTTOMS.*

By Henry A. Mather.†

While this device is not new in its inception, the peculiar advantages failed to be of practical utility until furnace builders instituted the mechanical reform of supporting the upper and lower water jackets by hanging them from an I-beam frame, independently supported by iron columns, instead of resting the entire weight of the structure on the bottom, as practice formerly prescribed. The Colorado Iron Works were among the first to build copper furnaces of this description, and the device, illustrated herewith, has been installed by them in three recent plants: Two furnaces for the Westinghouse interests near Ely, Vt., and one for the Grand Prize Copper Co., of Gila county, Arizona.

The jack-screw supports (Fig. 1 and 2) and the familiar iron bottom of former practice are retained as integral parts of this new furnace bottom. And, instead of resting inert on the tap floor of the furnace room, the jack screws are supported on and bolted to two I-beams the length of the furnace, placed immediately beneath and parallel to its sides. These I-beams are bolted to, and supported by, three steel axles equipped with small flanged wheels, the whole constituting a carriage which runs freely on a track. The entire apparatus is movable or rigid at will, or the wheels are easily braced, if the tension of the tightened jack screws does not serve to hold the whole in position.

The advantages of this design will be at once apparent to those who have had practical experience in barring furnaces provided with stationary iron bottoms. It is a well-known fact that the larger part of the time occupied in cleaning and preparing a frozen furnace for active service is necessitated by working in a confined place where the temperature is uncomfortable, and that in such case the debris must be removed from the bottom of the furnace before the false bottom of fireclay, coke breeze, etc., can be repaired or replaced. Then, too, this superimposed bottom is almost invariably destroyed when the iron plate is pried off the supporting jack screws, and no renewing is practicable until the plate is once more installed beneath the furnace.

Results from the working of the Grand Prize installation demonstrate that the time lost by "freezing up" is ordinarily reduced over 50%, and with good fortune more economy is possible. The work of barring down and renewing the false bottom proceeded practically simultaneously. The jack screws had a play of 10 ins. and the false bottom was built 9 ins. in depth, including firebrick cover.

If the truck carriage is slowly moved along its track and a hose played into the 1-in. of clearance space thus provided for, the suddenly cooled contents of the furnace (which are commonly untouched by water played from above) crack clear of the brick bottom; and, with the bottom edge of the water jackets acting as a scraper, very little, if any, of the false bottom is damaged. The major part of the furnace contents clings to the material wedged into the space immediately above the bosh, and the removal of the entire debris content is rapidly and easily accomplished. The false bottom, meanwhile, is easily repaired and renewed, and a very considerable saving of time is effected.

The extra cost of this device is not excessive; it is simple in construction and has few or no wearing parts, and it would appear to be a mechanical construction worthy of more general use, especially as there is no patent on either bottom or carriage.

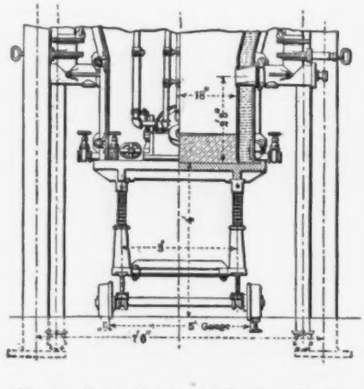



Fig. 1. Cross-Section of Furnace Showing Truck Support.

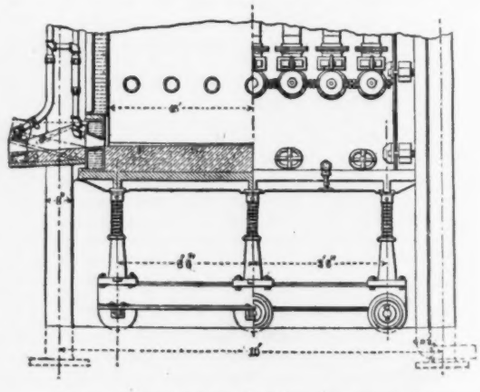


Fig. 2. Longitudinal Section of Furnace Showing Truck Support.

*A paper read before the American Institute of Mining Engineers, May, 1902.

†Chemical Engineer, 52 Beaver St., New York City.

## DRAWBRIDGE CALCULATIONS.

By Edward Godfrey.*

The common method of finding the reactions of a drawbridge is to consider it a continuous girder and use the theorem of three moments. This theorem assumes that the moment of inertia of the girder is constant and does not take into account the deformation due to shear, or, in the case of a truss, to web stresses. That this method does not give correct results is well understood.

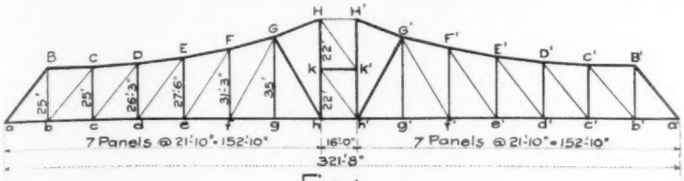



Fig. 1

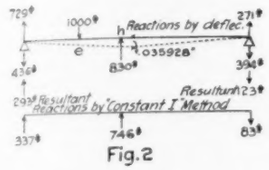



Fig. 2

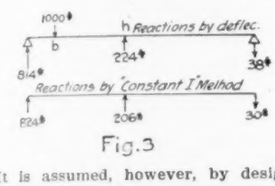



Fig. 3

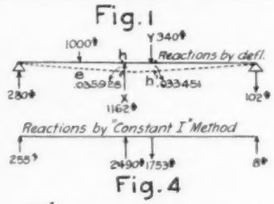



Fig. 4

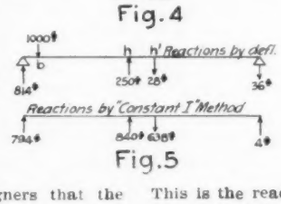



Fig. 5

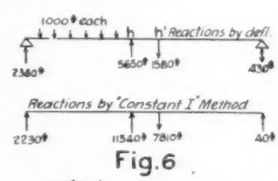



Fig. 6

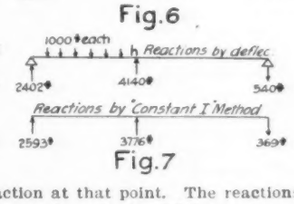



Fig. 7

It is assumed, however, by designers that the results are near enough for practical purposes. Any alteration in the theory of the continuous girder to account for the variation of the moment of inertia would simply complicate the formula and give results no nearer the true reactions, since the effect of the deformation due to the extensions in web members of a truss is often as much as that due to the chords. The problem can be solved, however, by calculation of the deflections. The solution is effected by means of the well-known deflection formula, namely,

$$D = \frac{\Sigma\, p\, u\, l}{E},$$

where D = deflection in inches of any point of a frame in any assumed direction under any given condition of loading; p is the stress in any member of the frame due to a load of one pound applied at the point whose deflection is to be found, the load acting in the direction in which the deflection is to be computed; u is the unit stress or stress per sq. in. in the same member resulting from the given loading; l is the length of the member in inches; E is the modulus of elasticity of steel, or 29,000,000 lbs. per sq. in.

To apply the deflection method the case of the truss shown in Fig. 1 was taken. This is a typical form of drawbridge and one now standing.

For dead load stresses due to a panel load of 16,200 lbs., the deflection of the end pins at each end, considering the truss a cantilever from a to h, and another from h' to a', was found to be 3.325 ins. The deflection of the point a due to an upward force of 1,000 lbs. was then found to be .0827-in. To lift point a a distance of 3.325 ins., or to bring it to the level of h, would therefore require,

$$\frac{3.325}{.0827} \times 1{,}000 = 40{,}200 \text{ lbs.}$$

This is, then, the reaction at a or a' considering the whole bridge a continuous truss over four points of support. By the theorem of three moments the reactions at a and a' are each 45,680 lbs., or 13.6% greater than the true reactions. In the calculations one-half of the top and bottom chords in the middle panel was considered as belonging to each cantilever.

To apply this principle in the case of a truss on three supports, it is only necessary to find the deflection at the middle support due to the given loading, considering the truss as one span from end to end, then to find the vertical force to lift the point back to its original position. Referring again to the same truss, and supposing it to have but one intermediate support, namely, at h, the deflection at h due to 1,000 lbs. at h was found to be .043045 in. The vertical force necessary to lift h a distance of .035928 in. is then 830 lbs. This is the reaction at that point. The reactions at a and a' due to these loads (1,000 lbs. downward at e and 830 upward at h), considering the whole truss as a simple span, give as resultants 230 lbs. upward at a and 123 lbs. downward at a'. Figs. 2 and 3 show the true reactions for loads e and b, as well as those found by the theorem of three moments.

The same method can be applied to find the reactions for a truss over four points of support, though the operation is more involved. To find the reactions at h and h' for any assumed loading, it is necessary to know the deflection at h and h' due to the given loading, also the deflection at h and h¹ due to 1,000 lbs. at h, also the deflection at h and h' due to 1,000 lbs. at h'. With these six quantities the reactions may be found by the following analysis:

Take for illustration a load of 1,000 lbs. at e. The shape of the line of the bottom chord of the truss will be as shown in Fig. 4. If now a vertical force x be applied upward at h, this point may be brought back to the horizontal line. This will force h' to a point above the horizontal line. A third force y at h' downward will bring that point again into the horizontal line, at the same time deflecting h. When these two forces x and y balance so as to make h and h' on a level with a and a', the amounts of the forces will be the reactions at h and h'.

Letting D = deflection at h due to loading.
D' = " " h' " " "
$D_1$ = " " h " " load x.
$D_2$ = " " h " " " y.
$D'_1$ = " " h' " " " x.
$D'_2$ = " " h' " " " y.

we have:

$$D - D_1 + D_2 = 0. \quad (1)$$
$$D' - D'_1 + D'_2 = 0. \quad (2)$$

These equations are true because the resultant deflections at h and h' must be zero. These values were computed for a load of 1,000 lbs. at e and found to be as follows: D = .035928, D' = .033451, $D_1$ = .043045 x, $D'_1$ = .041206 x, $D_2$ = .041206 y. $D'_2$ = .042211 y, x and y being in thousands of pounds. The solution of the equations, inserting these values, gives 1,162 lbs. for x and 340 lbs. for y. The whole truss is then treated as a simple span to find the end reactions. Figs. 4, 5, 6 give comparisons between the true reactions and those found by the theorem of three moments for the truss over four points of support. It is seen that except for the left support there is no agreement whatever.

It is important to note that this method of deflections shows that comparatively little shear is carried across the middle panel, an amount which is but a small fraction of that obtained by the theorem of three moments. Probably two live load panel loads would be a safe amount to allow. It is further seen that no great error results in considering the truss as continuous over three points of support and using the reactions of a continuous girder. The greater stiffness due to the increased depth of truss at the center is offset by the deflection allowed by the diagonals.

It is true that writers on this subject advocate the practice of considering a bridge of this sort to be continuous over three points of support, with nominal stress in the middle diagonals, or at least they state that this is the common practice. But they give no satisfactory reason why a shear which their formulas show to exist should be disregarded. If such a shear actually exists, it should unquestionably be provided for, especially with adjustable diagonals, since any rocking of the verticals would put these diagonals into action immediately, the play in the pin holes being taken up by the adjustment. One reason given for not considering the truss as continuous over four supports is that it is impracticable to hold the third support down against the heavy uplift. But the dead weight coming on that support would act to hold the truss down to the full extent of that weight, and for any excess shear the truss could be considered as continuous over three points of support.

It is quite clear that, if no middle diagonals are used, there will be no shear, since the vertical posts are free to rock. But, if this rocking is prevented or diminished by diagonal rods, these rods will be stretched and the lighter the rods the greater will be the amount of the stretch and consequently the greater the stress per square inch It is false reasoning, then, to conclude that since lighter rods will carry less total stress, they will be as safe as rods proportioned for the full shear, whatever that may be.

The results of this investigation are reassuring in that they furnish a sound basis for a practice which, though common, is the outcome of irrational assumptions.

*Monongahela Bank Building, Pittsburg, Pa.

## THE WOES OF THE SECTION BOSS.

A correspondent calls our attention to the verses printed below in a recent number of the "New York Sun," and suggests that they form a fitting companion, as a literary production, to "Meest McDonough's Bias'," printed in our issue of Nov. 27. We may add that they also furnish an instructive side light on the friction between different departments which sometimes occurs in the railway service, and occasionally in other corporations as well.

"Me father, me brothers," says Danny the boss,
"And all of me kin thot Oi iver have known
Has worked on the road since they laid the first tie—
Revered and renowned is the name of Malone.
For twinty-wan years on the siction Oi've toiled,
In the rain and the shine, in the summer and fall;
Because Oi was worthy, the roadmaster said,
They put me in here as the boss of thim all.

Sure, me life was contint whin Oi worked on the road,
And niver so much as a kick did Oi make;
But now Oi could quit any time of the day
When Oi think of me head and the way it does ache;
For it's aisy to do what the siction boss sez,
But, arrah, when you're bossin' a dozen or two
It's different sure; it's the truth that Oi shpake,
For it's hell if you don't and it's hell if you do.

First the roadmaster comes an' he looks at the job;
Sure, sez he, yer not doing this tracklaying right;
But it's Mr. White's blueprint, sez Oi, Mr. Flynn,
Domn the blueprint, sez he, domn the print and domn White.
Faith, ye'll do ez Oi tell you or get off the job;
Sure, Oi will, Mr. Flynn, sez Oi, bowin' a few:
And the Chafe Ingineer raised Nid the next day;
Sure, it's hell if you don't and it's hell if you do.

The superintendent comes 'long in his car.
Phwat the hell is the matter? Look here, Dan Malone!
But the Chafe Ingineer gave the orders, sez Oi.
Domn the Chafe Ingineer; let him lave you alone.
Thot's the way they go on, sure I'm shpaking the truth,
For the poor section boss has of troubles a few.
Sure, Oi'd rather be back tampin' ties by the day,
For it's hell if you don't and it's hell if you do."

# ENGINEERING NEWS

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The decision in the Northern Securities case seems to have given a very black eye to the "holding corporation" idea, and may lead to very far-reaching results. "Congress has the power," says the Court, "to say that no contract or combination shall be legal which shall restrain interstate trade or commerce by shutting off the operation of the general law of competition." That it meant to exercise this power when it enacted the Sherman law will hardly be questioned, and the subterfuges by which the trust-organizers have evaded the law begin to look rather weak.

Of course, nobody doubts that the law cannot compel two private individuals to compete if they actually do not want to. What the law can do is to refuse its aid and protection to those who would destroy competition. A corporation is a creature of law and can do nothing effectually without the pale of the law. It is only because of the law's protection that corporations have grown to such an extent. If it is illegal for the Northern Securities Co. to own the stock of competing railway corporations, is it legal for the Pennsylvania to own the stock of the Baltimore & Ohio, or for the United States Steel Corporation to hold the stocks of the numerous competing corporations, whose competition it was particularly organized to check? It may even be questioned whether those "trusts" which have effected an absolute consolidation of former competitors have a legal right to exist under this decision.

The need of action for the preservation of Niagara Falls is being agitated by the New York "Tribune," and the opinion has been expressed that unless prompt action is taken to check the water power development at Niagara, the time will come not many years hence when the flow of water over the great cataract will be so reduced that its beauty and grandeur will be forever destroyed.

We would strongly second every attempt to preserve for the nation and the world the natural beauty of Niagara; but the immediate danger is not so much the moderate amount of water subtracted from the cataract as the transformation of its vicinity by power houses and manufactories in such a manner as to greatly detract from the scenic effect.

When the first power house was built at Niagara, permission for the utilization of the water was only obtained on the plea that the power house was located so far away from the falls (over a mile) that it and the accompanying industrial development would not injure in the slightest the natural scenery around the great gorge. Had other power developments proceeded on similar lines, we believe that no objection could rightly have been raised; but when it was demonstrated that Niagara water power enterprises would pay, plenty of people were ready to undertake them by the easiest and cheapest plan.

Before that time, local sentiment in the vicinity of Niagara had been strongly opposed to anything tending to injure the beauty of the falls and make them less attractive to visitors. This local sentiment disappeared when it was seen that the industrial utilization of the cataract promised greater profits; and the result is the defacement of the great gorge below the falls with power houses, pulp mills, metallurgical works and other factories, with their attendant dirt and smoke.

For a long time the Canadian side was free from these vandalic enterprises; but within a few months, as described in our issue of Dec. 11 last, water-power enterprises have been undertaken on that side of the river which will be a greater disfigurement than anything yet undertaken on the American shore. A great power house is being built in the gorge, near the foot of the Horseshoe fall and another great power house is to stand close by the upper rapids.

A few years ago such desecration of one of the world's greatest wonders would have aroused a storm of protest. Now, it appears to be taken as a matter of course.

We are not arguing against the utilization of Niagara power. In this, as in other things, "the greatest good of the greatest number" should control; and all the power development now undertaken or projected at Niagara could be supplied without effecting greater variation in the flow of water over the precipice than occurs naturally through variations in the level of Lake Erie. We do not share the fears, either, of those who foretell the entire utilization of the volume of water passing over the falls, nor is it likely that even the half of it can be profitably diverted. The total power utilized at Niagara at present is only a little over 100,000 HP.; and while plans are on foot to develop three times this amount, the market for any such amount of power is not yet in sight.

What we do maintain is that the development of power at Niagara should be confined to works carried out on lines similar to those of the Niagara Falls Power Co., the power being taken from the river above the rapids, led to a power house far away from the cataract, and discharged through a tunnel into the gorge below the falls. This method not only saves the scenic features around the cataract from injury, but it is in accord with sound engineering principles. It utilizes the whole power of the fall, including the descent of the rapids above the cataract amounting to nearly 60 ft. In some of the current schemes of water-power development at Niagara now under way, the water is taken near the foot of these rapids.

We discussed in our issue of March 26 the current newspaper criticisms of the Mississippi levee system and the frequently repeated charge that the system is a failure. In the last report of the Mississippi River Commission will be found statements which lead one to wonder, not that crevasses have occurred in the levees, but that the great volume of water now passing down to the Gulf has been held so well within bounds.

On page 16 of that report is given a tabular summary of the levees in the several districts as they stood on June 30, 1902. This shows that the total contents of the existing levees on the Mississippi below Cairo at that date was 167,278,000 cu. yds., and the amount *required to complete* these levees is given as 94,054,000 cu. yds. It thus appears that the existing levee system as a whole represents only 64% of a completed system, or roughly, a little less than two-thirds as much earth has been placed in the levees as is required to give them the necessary height and strength to resist the known highest floods of the Mississippi.

There is a large variation in the different levee districts as regards the condition of the levees. In the Upper St. Francis levees only 385,000 cu. yds. had been placed, out of 5,462,000 cu. yds. required for their completion. In the Lower Yazoo district, the levees now contain 32,129,000 cu. yds., and 14,548,000 cu. yds. additional are required for their completion. In this district the report states that the levees aggregate 188 miles in length, of which three-fourths has the crown at a grade of 3 ft. above the highest water of 1897, which has been the standard height for levee construction, although the closure of the St Frances Basin and this year's flood records will probably compel this standard to be raised. But of these levees which are up to the standard grade in height, a large proportion are deficient in section, and of the remaining quarter of the line some is as much as 18 ins. below standard grade and is also weak in section. In the Pontchartrain levee district there are 41.32 miles of levees with a height less than 1 ft. above the 1897 high water mark.

We mention these only as typical examples of the present condition of the Mississippi levees. In view of these conditions, the absurdity of calling the levee system a failure because the present year's flood has overtopped and breached these embankments at their weakest spots is self-evident.

We stated in discussing this topic two weeks ago that the reason why the levees are not complete is simply lack of the necessary money. The work is paid for almost entirely by the localities benefited and the contribution of the United States Government toward the work cuts but a small figure. For example, in 1892, the local levee-boards placed 6,227,000 cu. yds. of earth in levees and the United States only 713,000, or little more than 10% of the total construction. Various modes of taxation are resorted to for raising funds in the levee districts. In 1902 the general property tax for levee purposes amounted to about $1,140,000, and about $800,000 more was raised by assessments of railway lines per mile and lands benefited per acre, and by taxation of produce raised on the levee-protected lands. In the Yazoo-Mississippi Delta levee district, a tax of $1 per bale on all cotton raised brought $157,532 to the treasury. It is of interest to note that in the Grand Prairie Levee district in Louisiana, an assessment is made of "one dollar on each and every arpent front of land facing the Mississippi." The total revenue of the levee districts in the fiscal year 1902 was a little less than $2,000,000. Doubtless the present year's flood will make the taxpayers willing to carry heavier burdens for the sake of better protection, and will result in considerable betterment of the levees before the next great flood appears to test them.

The "Progressive Age," a journal devoted to the gas industry, in its issue of the current month, takes us severely to task for our heretical views on the "municipal ownership" question, with special reference to our recent articles on the municipal ownership of gas works and our still more recent approval of Col. Munroe's proposed municipal street lighting plant for New York city. The "Age's" argument is the well-worn one of the dishonesty and corruption of municipal governments. It recognizes, of course, that the gas business is a natural monopoly, so that competition is not to be relied on for the public protection, and it advocates that state and city regulation should intervene for this purpose. We quote as follows from our contemporary:

The city and state, on the other hand, have some power

to regulate the business of private companies. Furthermore, we believe that the individual should be permitted to do business as long as he does it satisfactorily. In case any business is found not to serve the public well under private management, then let the general or local government step in and first attempt to regulate, and if that fails, to operate it.

In making this statement, our contemporary actually comes around to our own position. We are entirely in favor of leaving any and every business in private hands so long as the business is "done satisfactorily." It is because the business was *not* done satisfactorily that cities and states were compelled to intervene and undertake the task of regulation. Our contemporary well knows that 25 years ago American gas companies were running along in a rut, charging what prices they pleased for gas and earning such large profits that methods of economical production and management were largely neglected. These large profits led to an era of competition in the gas business and many millions of dollars were wasted and worse than wasted in needlessly duplicating gas works and lines of street mains.

Thus the old plan of treating the gas business as if it were a private business, like the baking of bread or the selling of milk (with which indeed our contemporary compares it) proved a total failure. It is now generally recognized that the gas business and the electric lighting business and the street railway business are natural monopolies, and as such must be regulated by the public authorities for the public protection.

Our contemporary says above that if public regulation of the gas business proves a failure then we should try public operation. That is exactly the situation. Public regulation has succeeded in some things; but it has undeniably proved a failure in others. Where it has proved a failure is where the demand arises for public operation. Do we need to tell our contemporary wherein public regulation has proved a failure? Is it not perfectly well known that in many American cities the franchise-holding corporations are in control of the city government and to a large degree of the state governments as well? The fact is that the franchise-holding corporations are the greatest source of political corruption in American politics to-day; and this is one strong reason why the tide of public sentiment is turning against the plan of regulation and favoring direct ownership and operation of municipal monopolies.

Our contemporary further takes exception to our criticism of the "gas companies of New York city," or rather of the huge corporation which has brought under a single ownership the entire gas and electric lighting interests of New York city. We shall not take space here to relate anew the story of the manner in which this consolidation was brought about. It is a matter of very recent history, and if its details have escaped the memory of our contemporary, we advise a perusal of the paper by Mr. R. R. Bowker, late Vice-President of the New York Edison Co., in the "Atlantic" a year or so ago. Mr. Bowker's scathing exposure of the political and financial methods by which the present lighting monopoly in New York city was created is excellent reading for any one who is in search of actual facts bearing on the disputed question of state control of public utilities vs. municipal ownership.

Finally, we strongly suspect that the editor of the "Progressive Age" assumes the defense of the New York lighting monopoly with no real heart in his work, but with a mistaken idea that it is his duty because his journal represents the gas industry. In proof of this we quote further as follows:

> Let it be recognized that the gas men of to-day desire nothing more than fair dealing. They are a body of men who are capable and successful in their business, careful of the interests of stockholders, conservative in policy, mindful of good service to consumers and energetic in the conduct of their business. *We do not include the banker, promoter, organizer or inventor in this classification*, but rather the gas company managers and directors of to-day.

The italics in the above quotation are our own, and it is a highly suggestive clause! We also have no indictment whatever to bring against the gas company managers, engineers and superintendents. It is the promoters and organizers, whose defence our contemporary is so careful not to undertake, who have robbed the public; and it is for protection against them that the safeguards of public regulation—and where necessary, public ownership—must be made available.

## AN ARGUMENT AGAINST LONG-TERM BONDS.

One of the wisest features of the Constitution of New York is that which restricts the creation by the State of interest-bearing debts, and provides that whenever the State resorts to an issue of bonds to raise money, such bonds shall not run for a longer period than 18 years. That period represents, roughly, the life of one generation; and the principle is a sound one that the people of one generation should not create a burden of debt for a future generation to pay. Coupled with this provision is another to the effect that no debt may be incurred by the State in excess of $1,000,000, except the act creating the debt be first approved by popular vote.

Had such wise safeguards been placed in the organic law of every State and municipality a half-century ago, it would have lessened by an enormous sum the burden of debt now carried by the taxpaying public throughout the country; and would have prevented a vast amount of wasteful expenditure.

It is often urged, when any great public work is under discussion, that as its benefits are to extend to posterity, it is fair that posterity should bear its share of the burdens. The fact is, however, that most of the public improvements which one generation makes are outgrown and obsolete by the time the next generation is at maturity. There are, of course, exceptional works which endure for centuries; but how few they are compared with those which are worn out or superseded in a brief score of years. Who is wise enough at the present day to look ahead a half-century and see what will be the wants and needs of the people living at that day? How can we be sure that the great works we plan to-day will be so valuable and beneficial to those who will then be living that we are justified in imposing on them a burden of taxation? Did the men of 1853 know much about the needs and conditions of the American cities and States of 1903?

We are well aware that there is a strong party in opposition to the sound and safe principle of public finance above laid down. Its motto is: "take care of the present and the future will take care of itself." It favors every expenditure of public funds, no matter at what cost obtained, since these expenditures make trade and business brisk, give employment to labor and foster booms in real estate. These considerations have weight with many who forget that a city or State cannot find permanent prosperity through mere expenditure of borrowed money any more than an individual, and that the law of action and reaction is as true in finance as in mechanics.

Another plea often put forward in justification of the transfer of burdens to future generations is that of necessity. It is said that this or that or the other improvement is essential to present welfare and prosperity, and that the present generation is already loaded with all the tax burdens it can stand. But why is it so burdened? Is it not because of a load placed there by a previous generation? And if a previous generation was unwise, ought its folly to be repeated by those now living? Is it not rather the part of wisdom to profit by the mistakes of the past and to make a start toward freeing States and cities from their loads of debt, rather than to go on creating new and heavier ones?

The above thoughts find a practical application in connection with the proposed 1,000-ton barge canal scheme in New York. The law as passed by the legislature, which is to be submitted to the people for approval next November, requires that the $101,000,000 bonds to be issued to pay for the canal work shall run for 18 years. The people are to be seduced to vote for the bill, however, by the argument that the bonds will be made to run for 50 years instead of 18. We quote as follows from a "catechism" for the instruction of voters which is shortly to be circulated by the New York organization which is promoting the canal scheme:

> Q.—What is submitted to the people? A.—Whether the state shall issue bonds to the extent of $101,000,000 for canal improvements.
>
> Q.—Why will these bonds be made for 18 instead of 50 years? A.—Because the constitutional change authorizing long-term bonds cannot go before the people before 1905. In the meantime steps have been taken to make the bonds extend 50 years.

Putting aside for the moment all arguments for or against the canal enterprise, we do not see how any reputable business man can justify the proposal to make these bonds run for so long a period as fifty years. What assurance can the men responsible for this enterprise give that their proposed 12-ft. channel will not be as obsolete a half-century hence as the existing 7-ft. ditch is at the present day? Even those who are most certain that the canal is needed at the present time must admit, if they are candid, that its usefulness fifty years hence or even twenty-five years hence, is extremely uncertain.

Reading on in the catechism we find the following:

> Q.—How long would it be before the direct saving to the people in the reduction of canal and rail rates would offset the cost of construction? A.—It has been expertly estimated that the reduction would return the entire cost ($101,000,000) in less than 10 years.

The barge canal advocates evidently have confidence enough in this "expert estimation" to submit it to the voters, so we suggest that they be guided by it themselves. If it is true that the 12-ft. canal will produce such large benefits to the present generation, then there is no reason why the present generation should not pay for it.

The provision forbidding the creation of long-term State bonds was placed in the Constitution for a wise purpose. Its presence there is a valuable safeguard to every dollar of taxable property in the State of New York. Every taxpayer and business man, every reputable commercial and financial interest in the State should strongly oppose its removal.

## LETTERS TO THE EDITOR.

### Asphalt Pavements in Washington on a Macadam Base.

Sir: In reply to your request in your issue of April 9 for information concerning the use of macadam as a base for asphalt pavements, I beg to give you the following examples of such a construction in Washington:

I St. N. W., from 23d St. to Pennsylvania Ave., 12 ins. of old macadam were resurfaced in 1891 with 1½ ins. binder and 1½ ins. top by the Barber Asphalt Paving Co., the contract price being $1.20. There were 630 sq. yds. Since the guarantee ran out, 1896, the district has spent $99.65 for repairs. The pavement is in excellent condition.

First St. N. W., between R and S Sts. The Barber Asphalt Paving Co. laid in 1892 binder and top on a 12-in. macadam base that had been down one year. Since the guarantee ran out in 1897 the district has spent $36 for repairs, and the pavement is in excellent condition. The street has a fairly heavy traffic. Contract price for macadam, 26 cts. per sq. yd. (extremely low); of paving, $1.20, making a total of $1.46. There were 2,000 sq. yds. The district was at that time paying in the neighborhood of $2 for a pavement on a 6-in. hydraulic base.

On the north side of Lincoln Sq. the pavement was laid over telford and has given good satisfaction.

A 10-in. macadam base here would to-day cost more than the 6-in. hydraulic, 1, 2 and 5 natural, or 1, 4 and 10 Portland

Thos. C. J. Baily, Jr.

1208 Lydecker Ave., Washington, D. C., April 11, 1903.

### Classification of Materials in Excavation Contracts.

Sir: The writer, while not a member of the American Railway Engineering and Maintenance of Way Association, was disappointed in not being able to avail himself of an invitation to be present during its recent meeting in Chicago.

He has not had time to digest the reports of its proceedings appearing in your issues of March 19 and 26, but the discussion of classification presented in the standard specifications for construction of roadway touches one of the most important details of railway building.

The writer believes the classification should be brief, elastic and entirely general in three classes. Any specification saying that the term "Earth" shall include certain materials, "loose Rock" others, and "solid Rock" still others is inherently defective as a standard by which to measure cost.

Earth and rock are subject to an endless variety of physical characteristics, to say nothing of those conglomerations that are neither one nor the other. A bank of fine gravel may be easily plowed and scraped; it may be partly cemented, requiring the vigorous use of a heavy pick, or it may be a solid aggregation quite as difficult to break as a granite ledge. It may be earth, loose rock or solid rock, as those terms are commonly understood.

Specifications ordinarily say that soapstone, shale, and

cemented gravel are loose rock, and, generally, if the Chief Engineer lives up to such a specific declaration, litigation results. If the cost of moving the material were regulated by the wording of the specifications, the case would be different; but the moment concrete terms are used, the necessary explanations and distinctions are as innumerable as the varying qualities of the material defined. An adequate and satisfactory classification of this kind has never been written except for special cases. The writer suggests the following specifications:

GRADING.—Grading shall include all excavations and embankments of whatever kind required of the contractor by the company in the complete construction and protection of that portion of the company's railroad and incidental work included in this contract on ground provided by the company.

CLASSIFICATION.—The materials in the excavations and embankments above specified shall be divided into three kinds, viz.: Class 1, Class 2 and Class 3.

Class 1 shall include all material of every kind which can be broken up successfully by a heavy, standard, 10-in. railroad plow, drawn by six strong draft horses or mules, each weighing not less than 1,200 lbs., and then be moved by ordinary scrapers or hand shovels.

Class 2 shall include all material of every kind which cannot be plowed, scraped and shoveled as above specified for Class 1, but can be successfully loosened by picks, bars or steam shovels into pieces less than 1 cu. yd., although blasting may be resorted to as a more expeditious and less expensive method.

Class 3 shall include all material of every kind in bodies of 1 cu. yd. or more which cannot be loosened by picks, bars or steam shovels, but requires continuous blasting to break successfully.

MIXED MATERIAL.—All material not, in the opinion of the Chief Engineer, clearly belonging to any of the classes above specified shall be classified by him as containing percentages of classes 1, 2 and 3, or any two of them, as, in his judgment, will be equitable to the company and the contractor.

Yours truly, J. L. Campbell.

911 Security Building, St. Louis, Mo., April 8, 1903.

### Stresses in Concrete-Steel Beams.

Sir: Referring to article by Mr. Thacher, "Are End Stirrups an Advantage in Concrete-Steel Beams," in your issue of March 26, the writer agrees with Mr. Thacher that no stirrups are required as long as no crack has appeared on the tension face. This crack, in a properly designed beam, should appear long before the elastic limit of the steel is reached, and this property makes the concrete-steel beam superior to that of the steel alone. The crack once having formed itself, the tension on the concrete must be eliminated, and this omission influences not only the horizontal stresses in the beam, but the vertical stresses as well.

Fig. 1.

Fig. 1 will make this clear. Before the crack has appeared, the internal stresses will follow the curved lines, the heavy lines denoting compression and the broken lines tension. These lines intersect the neutral axis at 45°. For this condition equilibrium exists throughout, for the internal stresses, and no stirrups would be required. However, when the crack has appeared, the broken lines, denoting tension, should be eliminated; the heavy curved lines then become straight lines below the neutral axis, owing to the influence of the tension on the concrete having been eliminated. These lines intersect the neutral axis at 45°, and continue in straight lines until they meet the metal reinforcement, when they are at once converted into horizontal and vertical components, which are equal to each other, their resultant being inclined at 45°. The horizontal components produce the pull on the metal, and the vertical components must be taken care of by means of stirrups. The analysis now becomes very simple.

Assuming a beam uniformly loaded, and neglecting the tension on the concrete, when the lower face shows a crack, the shearing forces carried by the stirrups is the vertical component of the forces producing a pull on the metal in a horizontal plane. The metal in a plane inclined to the horizontal, produces compression directly in the concrete without the aid of the stirrups. These forces below the neutral axis, act at 45°, and are all inclined in one direction, that is, towards the center.

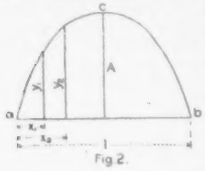


Fig. 2.

In Fig. 2, let A denote the sectional area of the metal in a horizontal plane, then the area of metal required in the stirrups at any point becomes

$$y_2 - y_1 = \frac{4\,A}{l}\left\{(x_2 - x_1) - \left[\frac{x_2^2 - x_1^2}{l}\right]\right\} \quad (1)$$

The curve a—c—b is a parabola, with its vertex at c.

If the area is to be found at every foot of the beam $(x_2 - x_1) = 1$, equation (1) becomes

$$y_2 - y_1 = \frac{4\,A}{l}\left\{1 - \frac{x_2 + x_1}{l}\right\} = \text{area required in stirrups.}$$

$$\text{Area in stirrups, 1 ft. from support} = \frac{4\,A}{l}\left\{1 - \frac{3}{l}\right\};$$

$$\text{Area in stirrups, 2 ft. from support} = \frac{4\,A}{l}\left\{1 - \frac{5}{l}\right\};$$

$$\text{Area in stirrups, 3 ft. from support} = \frac{4\,A}{l}\left\{1 - \frac{7}{l}\right\};$$

and so forth.

In a recent example, the metal in the horizontal plane was 0.03655 sq. in. per 1-in. width of beam. As the beam was 7 ft. long, l was 7 ft. The metal required in the stirrups, 1 ft. from the end, was

$$\frac{4 \times 0.03655}{7} \times \frac{4}{7} = 0.012 \text{ sq. in. per 1-in. width of beam.}$$

The metal required in the stirrups 2 ft. from the end was found in a similar manner.

The above analysis has been in use in this office for some time. Yours truly,

J. W. Schaub, M. Am. Soc. C. E.

1650 Monadnock Block, Chicago, March 28, 1903.

### Screw-Jacks for Pulling Piles.

Sir: In your issue of Feb. 26, "S. G. T." writes, inquiring as to how piles driven in very hard ground may be removed. Perhaps the most effective way is to spike a block of wood on one side, or if the pile be very refractory, on two sides, and put one or two jacks, as the case may require, under the blocks. A few turns of the jacks will surely start the pile. Respectfully,

E. M. Malmquist.

3324 Bell Ave., St. Louis, Mo., March 22, 1903.

### A Pile Pulling Rig Used in Kansas City.

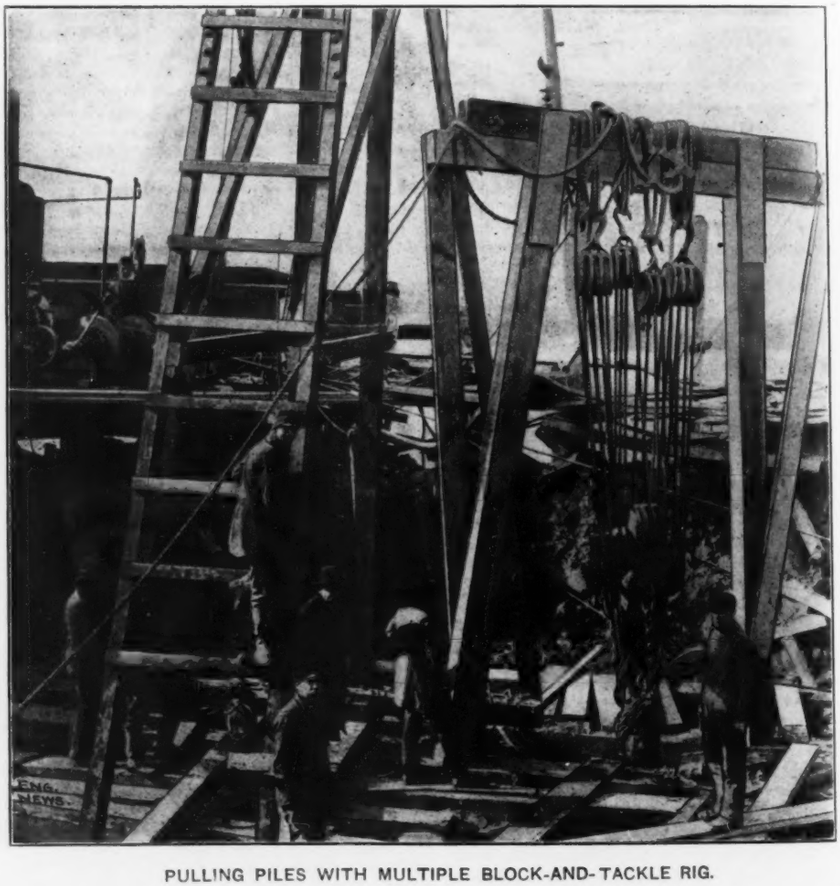
Sir: Under "Notes and Queries," in your issue of Feb. 26, S. T. G. asks for information regarding the difficulty of pulling piles. Under the circumstances the enclosed sketch may be of interest.

In excavating for a foundation for a pump-house intake on reclaimed land it became necessary to pull some old piles. These piles average 10 ins. at top, 18 ins. at butt and 40 ft. in length, and the rig used in pulling was four triple and four double blocks, making a ratio of 21 to 1. The 1⅛-in. hoisting line was attached to a 25-HP. engine. A jet from a 7-5-10 duplex pump was also used.

After rigging up it generally took about half an hour to pull the pile, the delay being caused by the inability of the boiler to keep up steam. The work in question is being done by A. M. Blodgett, Civil Engineer and Bridge Contractor, for the Metropolitan Street Ry. Co., of this city. Yours truly,

Wm. P. Parker.

405 Thayer Bldg., Kansas City, Mo., March 9, 1903.



PULLING PILES WITH MULTIPLE BLOCK-AND-TACKLE RIG.

### Failure of Tubes in Boilers Fired by Mechanical Stokers.

Sir: In the issue of Engineering News for March 26, 1903, article on "Some Recent Tests of Mechanical Stokers," by G. A. Hutchinson, contains the following quotation:

The coal now used altogether for hand firing, which has been broken and washed at the mine, but not screened, was tried. It had to be given up because the ash and fine coal rapidly fill the combustion chamber and melted into a slag mass. The path of the burning gases was restricted and such an intense heat was concentrated on the tubes that they rapidly gave out.

If this statement can be taken as fact, it perhaps throws some light on the conditions which the writer recently found in one of a battery of two boilers. Both batteries were alike in all respects, with the exception that one, the older, was hand fired and the other was equipped with mechanical stokers. From the time the new battery was put in service trouble was continually experienced with the tubes failing. So far as could be ascertained there was no reason why the tubes in the new battery should fail while those in the older one were perfectly satisfactory, unless the conditions should be the same as those given in the above quotation from the article referred to.

It would surely be of general interest to your readers if others would give their experience, corroborating or discrediting the above statement. Yours truly,

J. Jay Dunn.

Shelby, O., April 8, 1903.

### "Subscriber's" Problem in Bridge Design.

Sir: The bridge proposed by "Subscriber" in your issue of March 19 is evidently a statically indeterminate structure of the second degree. The main stresses, which are in the chords, will become a minimum if the center hinge at E, is left out, but this will make the bridge statically indeterminate in the third degree. The construction is arranged to best advantage when the end abutments can obtain only little resistance. To judge from the sketch the height of the bridge seems great compared with the length. The influence of the temperature is therefore of little importance, but has of course to be taken into account.

The proposal already made of substituting a longitudinal joint at E, I do not understand. This seems to me to be a cantilever construction with the suspended span left out, consequently a statically determinate construction; this would miss the advantage of either a two or a three-hinged arch in the main span and would require an anchor at A and D.

I would suggest to take the full advantage of a two-hinged arch (which theoretically gives smaller stresses and is easily erected in accordance with the calculated con-

ditions) having a hinge at E during the erection and later leaving it out. But I would put in a hinge at F and G; this would have the great advantage of making certain that the erected bridge would give resistance in accordance with the calculations, which otherwise would be very hard to obtain, due to the end abutments being high or low. Changes of stresses from tension to compression in the cantilever arms would be avoided.

As to the calculations of this bridge, the vertical resistance at A, B, C and D would be obtained in the same way as a cantilever bridge, and the only statically indeterminate power, the horizontal thrust H, in the usual way by drawing the influence line.

T. B. M.

Pittsburg, Pa., March 30, 1903.

(The preceding does not answer the question asked, which was: Explain methods of finding reactions and position of loads for maximum stresses. In merely mentioning the use of influence lines our correspondent misses the difficult part of the problem, which is to determine the influence lines.

The omission of the center hinge and the insertion of hinges at F and G transforms the structure into what is undoubtedly a simpler one. It gives a two-hinged arch with cantilever side spans, like the Costa Rica arch described in Engineering News of Oct. 23, 1902. The three-hinged arch with side arms anchored down at the ends, as in the problem before us, is a more difficult problem of design, however. It should be remarked that our previous suggestion of converting the center hinge into a sliding joint would not give a statically determinate structure, as the writer of the above seems to believe; the vertical constraint at the center would leave the structure singly statically indeterminate. It is clear even on inspection that the fraction of load transferred across this sliding joint would be greater or less according to the stiffness of the half-sections of the span.—Ed.)

### Stresses in a Combined Cantilever and Three-Hinged Arch.

Sir: In your issue of March 19 appears a communication from "Subscriber," asking for a solution of the stresses in a truss like the one shown in Fig. 1.

Fig. 1.

Any formula or summation of general application for proportioning such bridges direct would doubtless be worse than those for the two-hinged arch. It can be shown that what seems to be the prevailing method for proportioning a two-hinged arch gives for the first trial only a guess, and that guess is based on theoretical stresses and areas. These areas may be too small for some parts to be realized in built sections, and herein lies the fallacy of proportioning the truss in a purely theoretical way. On the other hand, if built sections are proportioned to suit the magnitude of the truss, a variation of the areas used may be effected when stresses are found.

For proportioning the truss shown in the figure I would suggest that each web member be designed to take a compressive stress equal to two full panel loads, and that the chords throughout be designed for a compressive stress equal to four panel loads. This will give a basis for finding deflections and making the application of the deflection method.

To apply the deflection method, assume a load of 1,000 lbs. applied at the center pin A in a horizontal direction. Then find the stresses due to this in all of the members, and apply the deflection formula

$$D = \frac{\Sigma p u}{E};$$

in which D = deflection in inches in a given direction, p = stress in any member due to a load of 1 lb. applied in that direction, u = unit stress in the member due to the given loading, l = length of member in inches, E = 29,000,000. The application of this formula will give the horizontal deflection at A due to the load of 1,000 lbs. Next find the vertical deflection due to the load b of 1,000 lbs.

The next step in the process is to place any panel load on the truss and calculate the stresses as a cantilever, as shown in Fig. 2. From these stresses, using the same deflection formula, find the deflection horizontal and vertical at A. These deflections will be resisted by the other arm or half of the system; and since they are both equally rigid, the resultant deflections will be just one-half of those found for the free arms. The forces applied at A, to cause the point to return over one-half of these deflections, will be a horizontal and a vertical force applied as a and b, the amounts of which will bear the same ratio to 1,000 lbs. as the deflections bear to the deflections found for the 1,000-lb. loads.

The stresses due to the panel load combined with those due to the horizontal and vertical forces at A will be the

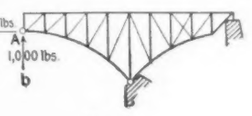



Fig. 2.

correct stresses for the sections assumed. On the half of the bridge not loaded, only the horizontal and vertical forces act.

In the same way as outlined above the stresses for each panel load may be worked out. Of course, methods will suggest themselves for shortening the work. When all of the stresses of the same sign are combined, the worst stress for each member may be found. Then a reproportioning of the truss would give close to the correct sections. A repetition of the work would doubtless give stresses practically correct.

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Mar. 24, 1903.

### Specifications for Wood Water Tanks and Stress Diagram for Hoops.

Sir: I see in your issue of March 5, 1903, an article on the construction of water tanks, by Messrs. Ballinger & Perrot. These specifications correspond very closely to

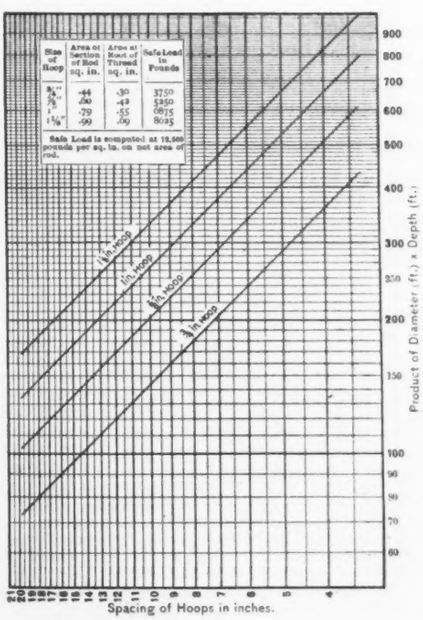



DIAGRAM SHOWING ALLOWABLE SPACING OF HOOPS.

Spacing of Hoops in inches $= \frac{\text{Safe Load for given Hoop in lbs.}}{2.6 \times \text{dia. (ft.)} \times \text{depth (ft.)}}$

some that were published by this Inspection Department in November, 1901, a copy of which you will find enclosed. The diagram for computing the spacing of hoops given by Messrs. Ballinger & Perrot I do not think is in such convenient form as the diagram shown on p. 6 of our specifications. This diagram was arranged by Mr. Chas. H. Smith, of this office; and, as you will observe, by the use of logarithmic cross-section paper, gives a single straight line for each size hoop, and by one simple multiplication, the proper spacing of hoops at any depth and for any size of tank can be determined from the diagram, as explained under Art. 4 of the specifications. Trusting you will find this of some interest, I am,

Yours truly, Macy S. Pope,
Inspector Factory Mutual Fire Insurance Cos.

31 Milk St., Boston, Mass., April 1, 1903.

(The diagram mentioned by Mr. Pope is reproduced herewith. The specifications from which the diagram is taken appear to have been drawn with great care. They are elucidated by numerous explanatory paragraphs, in small type, and by sketches showing details of construction. Truly, these specifications seem well designed to "fill a long felt want," and it seems a pity that they cannot be made generally available; if, indeed, they are not already so.

In an introductory note it is stated that the specifications were prepared as a result of numerous recent failures of wood tanks, and inquiries as to how they should be constructed to avert failures. No claim is made for the introduction of new features, but attention is called to two requirements. (1) Round instead of flat hoops; and (2) "tanks of greater strength than are often furnished by the trade." Doubtless, however, "the trade" would gladly furnish heavy tanks if purchasers would recognize their desirability and pay the comparatively slight cost thereof. The pamphlet also contains some notes on steel tanks, and on painting steel tanks and trestles.

Perhaps it should be added, lest a misunderstanding should arise from the use of the words "these specifications" in the second sentence of Mr. Pope's letter, that the article by Messrs. Ballinger & Perrot did not contain full specifications for wood tanks, but related to the hoops only.—Ed.)

### The Metric System in Mexico.

Sir: To one who has had more than 18 years' practice with the metric system of measures on railways in Mexico, and is prejudiced in its favor, some of the arguments (?) advanced by its opponents appear weak. For example, Mr. A. S. Robinson's difficulty with stake numbering. The practice he mentions is not the most common; neither is it necessary, nor the more convenient method. Also the profile paper: Why does "Plate A" have to be used? One may as well say that all profiles must be platted to a certain fixed scale. The profile paper used on a majority of the railways in Mexico is the metric, with both horizontal and vertical lines ruled one millimeter apart—5th, or 10th, and 50th lines ruled more heavily. A convenient profile for railway work is a horizontal scale of 1 to 4,000, and vertical of 1 to 200. Rod readings for cross-sections should be taken at breaks in ground slopes, rather than at distances apart of 10 meters, 20 meters, or even 100 ft.

The difficulty in deflections for fractional stations, referred to, can easily be overcome by a further application of the decimal system, i. e., by dividing one of the verniers into 100ths, instead of 60ths of a degree.

According to some of your correspondents, we should have several different units for measuring different magnitudes—the inch, foot, yard, rod, and mile. Pursuing the same line of thought, why not have different units of money? other than the decimally constructed dollar only, one unit for buying and selling buttons, another for hats, another for horses, another for houses, another for railways, etc., ad libitum?

Any decimal system with a smaller, or larger unit than the meter, would be intrinsically as good as the metric, but for the fact that the metric is already extensively used in many different parts of the world.

In these days, since international commerce is increasing so largely, it certainly would be an advantage to have an uniform, or at least easily understood system of weights and measures, to the manufacturers as well as to the engineering and other professions.

There is probably no urgent need for legislation, either for or against the metric system. If it cannot obtain on its own merits, it should not on other grounds. Its use is extending, and will continue because it is a labor-saving "scheme," sensible, simple and practical. It possesses the same advantages over the foot and yard system, that our "dollar" does over "pounds, shillings and pence." Its use is in line with the best engineering practice, of accomplishing results with the least expenditure of time and money. Yours faithfully,

T. A. Corry.

Puebla, Mexico, March 24, 1903.

(Practically the metric system has different units for measuring different magnitudes. For example, the mechanical engineer uses the square centimeter; cloth is measured by square meters; land by acres and hectares. The decimal relation between these different units is certainly a convenience in connection with computations. The

metric advocate objects to the English system of weights and measures, not because it has different units for different magnitudes, but because these units are not decimally related to each other.

But if this decimal relation were so vastly important as our metric friends claim, we could alter our English system to conform to it without the slightest trouble. We could just as well measure distances in thousands of feet as in miles; land in units of 100 sq. ft. on a side, as in acres; excavation in cubic feet or in units of 1,000 cu. ft., as in cubic yards. For fractions of a foot, tenths can be used as well as inches; and are used in a great deal of engineering work. In lumber the decimal measure already exists. Everybody knows that "M ft. B. M." means 1,000 sq. ft. of boards 1 in. thick or its equivalent in volume in lumber of greater thickness.

Again, very much is made of the direct relation between measures of length and measures of capacity in the metric system; but *if it were worth the trouble*, we could have the same with the English system. It is just as easy to measure water in cubic feet as in gallons, and a vast amount of water is already measured in that way. It would be easy to give names to the tenth and hundredth of a cubic foot and use them in place of the present gallon and pint.

The fact is that the multiplicity of units in our English system of weights and measures are the result of custom and convenience, and they can be and will be discarded whenever anything is to be gained by so doing. Many of them in fact have become obsolete, but others continue in use because it is more convenient to use them than to make a change. For example, it would be a slight convenience to the engineer to measure earth work in cubic feet instead of cubic yards; but a cubic yard is a unit to which those who handle earth work are accustomed; moreover it is a convenient unit, corresponding approximately to a cartload. It is easier to comprehend the meaning of "350 cu. yds." in a fill than its equivalent "9,450 cu. ft." Probably the convenience from the use of cubic yards far outweighs the inconvenience to the engineer of having to reduce cubic feet to cubic yards. At any rate, we have strong faith that the question will settle itself and that legislators cannot interfere with any certainty of benefit.—Ed.)

## The Origin of the Metric System—Experience with the Metric System Abroad.

Sir: Much has appeared in your columns lately about the metric system, but very little which gives any reasons or causes for its coming into existence. The system has been much discussed, too, but only from certain narrow standpoints. Among all the articles, I have noticed none which seems to take any broad view of the question,* and particularly is this true of its opponents.

Few persons have any idea of the tangled and confused condition of weights and measures in Europe 120 years ago. Every province in France differed from all the others. Germany and England were hardly any better off, if at all. Although many persons had noticed the difficulties which surrounded commerce by reason of this confusion, it was not until the latter half of the seventeenth century that any suggestion of a uniform system was broached. Some attempts at reform had been tried, but they were all doomed to failure by a state of society which gave each lord a very nearly complete administrative independence on his own lands. The popular mind could scarcely see the usefulness of a reform whose only object seemed to be the substitution for measures, arbitrary to be sure, but understood by those interested, other measures not less arbitrary and, in addition, ill understood and insufficiently defined.

In order that a reform which touched each real scientific and economic interests could succeed, the proposed system had to be derived from a single invariable modulus, susceptible of being measured with extreme precision, and easily found at all times and in all places, hence taken from nature herself. Furthermore, the choice of the modulus must not wound any national pride and must, consequently, be independent of the positions of the different countries on the surface of the globe.

The first propostions in this direction were conceived nearly simultaneously by Huygens, Picard and Mouton, about 1669-73. The first two favored the simple seconds pendulum, the last proposed the geometric foot equal to the 1-600,000 part of the degree on the earth's surface. To preserve its length it was noted that a pendulum of this length would oscillate 3,959⅛ times in half an hour.

In 1718, Cassini suggested taking 1-6,000 part of the minute of the degree of longitude, or 1-10,000,000 of the terrestrial radius.

In 1747, La Condamine, continuing the works of Du Fay, presented a very interesting memoir on the advantages of the simple seconds pendulum; on the necessity of substituting the decimal for the quodecimal system; and on the importance of expressing in round figures the measures of surface, volume, capacity and weight.

Here are all the essential elements of the question; but, although the idea became gradually more complete and precise, it did not seem ready, even at the dawn of the French Revolution, to leave the domain of pure science. The subject of a uniform system of weights and measures was brought up by Talleyrand in the National Assembly of France in April, 1790. After much discussion the Assembly passed, on May 8, 1790, a decree which was sanctioned by the king on August 22, 1790. As this decree is, in a way, the certificate of birth of the metric system, it is quoted here entire:

> The National Assembly, desiring to endow the whole of France for ever with the advantages which must follow from uniformity of weights and measures and wishing that the ratios between the old and the new be clearly determined and easily seized (understood), decrees that His Majesty be begged to give orders to the administrations of the various departments of the kingdom, to obtain and cause to be remitted by each of the municipalities of each department and sent to Paris, to be turned over to the Secretary of the Academy of Sciences, a perfectly exact copy of the elementary weights and measures therein in use;
>
> Decrees then that the king be also besought to write to his Britannic Majesty and to ask him to engage the Parliament of England to concur, with the National Assembly, in fixing the natural unit of weights and measures; that in consequence, under the auspices of the two nations, commissaries of the Academy of Sciences of Paris may join with an equal number of members selected from the Royal Society of London, at the place which shall be judged respectively the most suitable to determine, at latitude 45°, or any other latitude that may be preferred, the length of the pendulum and to deduce therefrom an invariable modulus for all measures and all weights; that after this operation performed with all necessary solemnity, His Majesty be besought to charge the Academy of Sciences with fixing precisely, for each municipality of the kingdom, the relations between their old weights and measures and the new modulus and then with preparing for the use of the municipalities, usual and elementary books in which these propositions shall be clearly laid down.
>
> Decrees, besides, that these elementary books be sent at the same time to all the municipalities, to be there spread abroad and distributed; that at the same time there be sent to each municipality a certain number of new weights and measures, which shall be delivered gratuitously by them to those whom this change would involve in too great expense; finally then, six months only after these deliveries, the old measures will be abolished and replaced by the new.
>
> The National Assembly decrees that the Academy, after having consulted the officers of the Mint, give its opinion on the question of knowing whether it be well to fix invariably the fineness of the coined metals, so that coins can never be changed except in weight, and whether it be not useful that the difference allowed in minting, under the head of tolerance, be always in excess of the weight laid down by law, but that it be never inferior thereto.
>
> Finally, that the Academy name the scale of division which it believes best suited, both for weights and for other measures and for coins.

The Academy began work at once and, on Oct. 27, 1790, a first commission, composed of Borda, Lagrange, Lavoisier, Tillet and Condorcet, presented its report on the fineness of the minted metals and the uniform scale of division, and gave the preference to the decimal division over the duodecimal.

On March 17, 1791, the commission, composed of Borda, Lagrange, Laplace, Monge and Condorcet, presented to the Academy its report on the choice of a unit of measure. It deemed that there were but three possible units, the seconds pendulum, the arc of the equator, the arc of the meridian.

The first introduces a heterogeneous element, time; and an arbitrary element, the division of the day into 86,400 seconds. One of the arcs introduces no element but that of length. The arc of the equator was discarded because only a few peoples live near it, whereas some nation lives on every meridian. So the commission recommended the ten-millionth part of the quarter of the terrestrial meridian as the ordinary unit of length. It also recommended that the arc be divided decimally, that is into 100 degrees of 100 minutes each, and these last into 100 seconds.*

To determine the quadrant, an arc of the meridian was to be measured from Dunkirk to Barcelona, from 6° north of the middle parallel of laitude to 3° 30′ south. This arc had the great advantage of both ends being at the level of the sea.

The operations necessary to determine the basis of the new system were to be:

1° Determination of the difference of latitude between Dunkirk and Barcelona.
2° Measurement of old bases.
3° Verification of triangles and extension of the chain.
4° Observations of the pendulum at 45°, north latitude.
5° Verification of the weight, in vacus at the temperature of melting ice, of a given volume of distilled water.
6° Reduction of the old measures to the new.

The Commissioners proposed to the Academy that a separate commission be appointed for each operation. They added that they had not thought it worth while to wait for the co-operation of other nations because if the record of the work were lost, and only the results remained, those lost would have nothing to show what nation conceived the idea on which nation carried it out.

The work of the Academy was presented to the legislative bodies, and on March 26, 1791, the Assembly adopted the report and gave the necessary orders for taking up the work recommended.

The Academy at once named five commissions:

1° Cassini, Méchain and Legendre, to determine the difference of latitude between the extreme points used to measure the triangles.

2° Monge and Mensuier, to measure bases.

3° Borda and Coulomb, to observe the pendulum.

4° Lavoisier and Hauy, to find the weight of distilled water at 0° and in vacuo.

5° Tillet, Brisson and Vandermonde, to make the comparisons between the new and the old measures.

These commissions were changed further on, and Delambre and Méchain alone were especially charged with the geodetic and astronomical operations, which were only to be finished eight years later.

While these operations were going on, the Academy studied the nomenclature. On July 11, 1792, a report was submitted on lineal and superficial measures, and on Jan. 19, 1793, a report on the unit of weights and the nomenclature of their divisions. Finally, Borda, Lagrange and Monge presented, May 29, 1793, a final report, summing up and modifying the others.

Two systems of nomenclature were presented. In the first the names were simple, monosyllabic and independent of each other; in the second the names were compound and gave the decimal relations between each other. Preference was given to the second, as the one with fewest names, and those different from the known measures.

Under the Revolution, and in spite of the abolition of the Academy of Sciences, the work went on steadily, the convention retaining all the interest shown by its legislative predecessors. On 18 Germinal, year III. (April 8, 1795), the convention decreed:

> Art. 2.—There shall be but one single standard of weights and measures for the whole republic; it will be a platinum rule on which shall be marked the meter which has been adopted as the fundamental unit of the system of measures.
>
> This standard shall be executed with the greatest care, in accordance with the experiments and observations of the commissaries charged with its determination, and it shall be deposited with the legislative body, as well as the report of the operations which shall have served to determine it, in order that it may be verified at any time.

Nothing could be definitively settled until the length of the quadrant had been determined. The measurements of the arc had been carried out through unheard of difficulties, the recital of which reads like a romance. Those who had had charge of this work returned finally to Paris and found there the foreign commissaries who had been invited to convene 15 Vendémiaire year VII. (Oct. 7, 1798).

The savants named to take part in the verification of the work and the final settlement of the fundamental units met in Paris on 25 Vendémiaire, year VII. (Oct. 17, 1798). They were MM. Aenea (Batavian Republic), Balbo (Sardinia), afterwards replaced by Vassalli Eandi; Brisson (France), Bugge (Denmark), Ciscar (Spain), Fabbroni (Tuscany), Franchini (Roman Republic), Haüy (France), Lagrange (France), Laplace (France), Lefèbvre-Gineau (France), Legendre (France), Mascheroni (Cisalpine Republic), Méchain (France), Multedo (Lizurian Republic), Pedrayes (Spain), Prony (France), Trallès (Helvetic Republic), Van Swinden (Batavian Republic).

This body is international. Had not France been at war at the time, it is likely that the foreign delegates would have appeared in larger numbers. Committees were appointed to verify all the work done on measuring the arc, on establishing the length of the meter in terms of the "toise du Pérou," and this with those of the North and of Mairan; and on fixing the unit of weight. The final report was read on 29 Prairial, year VII. (June 17, 1799), and the lengths of the meter placed definitively at 443 lines $\frac{296}{1,000}$ of the "toise du Pérou." The weight of the kilogramme in vacuo was fixed at 18,827 grains.

The prototype standards in platinum of the meter and kilogramme were deposited in the national archives on 4 Messidor, year VII. (June 23, 1799). The metric system with these standards was formally adopted and legalized on 19 Frimaire, year VIII. (Dec. 10, 1799).*

Such, then, in brief, is the history of the metric system. Conceived by men of science of the highest order, in a nation whose scientific ability has never stood below first, a nation of wonderful logical conception and clearness of thought and expression, the metric system, as a system of weights and measures, is the nearest approach to perfection yet devised. It contains all the elements of simplicity. It is decimal, and so conforms to our decimal system of arithmetic; its units are few; the relations between the units and their multiples and sub-multiples are clearly expressed and easily learned.

There is, however, nothing sacred in the meter per se, and those who favor the metric system hold to the meter only as the base of the best and the only logical system of

*Since the above was written Mr. A. T. Hubbard's article has appeared in your issue of Feb. 12, 1903.

*It may be noted here that the instrument used in measuring the angles of the geodetic work were divided centesimally.

*See the "Annuaire du Bureau des Longitudes" for 1901.

weights and measures yet devised. As a matter of fact any unit of length whatever may be used as a base. The value of the metric system lies not in the meter as a unit of length, as nearly all of its opponents seem to think, but in the intimate relation between the units of length, capacity and weight.

To illustrate this point let two cases be taken, one metric, the other ordinary, but fairly close together. For example: How much water does a vessel measuring 3 × 4 × 5 meters hold? And what does the water weigh? Let it be remembered that a liter, the unit of capacity, is the cube of a decimeter; and that the gramme, the unit of weight, is the weight of a cubic centimeter of water at its maximum density. There are three 1,000 liters in a cubic meter, or 1,000,000 cubic centimeters.

Now 3 × 4 × 5 = 60 cubic meters; 60 × 1,000 = 60,000 liters; 60 × 1,000,000 = 60,000,000 grammes. But 1,000 grammes = 1 kilogramme; and 1,000,000 grammes = 1,000 kilogrammes = 1 ton. So the vessel holds 60,000 liters, and the water weighs 60 tons.

In our ordinary measures the dimensions of this vessel would be in round numbers 10 × 13 × 16 ft. = 2,080 cu. ft. To obtain the amount of water it must be remembered that a gallon = 231.17 cu. ins.; and that a cubic foot of water weighs 62.43 lbs.

This superiority in matters of calculation runs all through. In earth work, for example, our engineers measure in feet and express in cubic yards. In other words there must be always a division by 27.

Several years ago the writer was connected with the improvement of the Ohio River. The subject of movable dams was just coming to the front in the United States. As movable dams were wholly a French invention, the entire literature of the subject was French. Naturally all dimensions were expressed and all calculations made in accordance with the metric system. Since that time, now nearly 30 years ago, the writer has saved great amount of time in his American work by transforming his feet and inches into meters, making his calculations and transforming back his results.

For more than four years the writer has been living in France, Belgium and Germany; he has been in the country and in many cities; he has visited factories and public works, and nowhere has he found anything but the metric system in use. Mr. Halsey (in Engineering News of Dec. 11 last) to try to prove a point takes a single industry wherewith to adorn his tale. But why does he not offset this with our so-called "system" in the one matter of board measure. Can there be anything more absurd when one stops to think of it? We are accustomed to it and so do not think of it.

The half kilogramme is called frequently "livre" in France and "pfund" in Germany. The cubic meter of fire wood is called frequently in France a "stere." All the same, these measures belong to the metric system, as everyone knows what they mean, just as everyone knows that a ton is 1,000 kilogrammes.

When we come to land measure, what is the side of a square which contains an acre? It can only be laid out approximately. In the metric system the unit is the arc or 100 square meters = 10 × 10 meters.

Now what are some of the objections made to the metric system?

1. That the meter is not 1-10,000,000 of the length of the quadrant from the north pole to the equator. That is granted, but to what extent does that affect the system? Not in the slightest. The length of the meter was determined as accurately as the instruments and methods of 100 years ago would permit, and the latest refinement have discovered an error of less than 2-100 of 1%; in other words 1,860-10,000,000, far closer than work is done in all the practical needs of life.

2. That the cubic decimeter of water at its maximum density does not weigh a kilogramme. In this connection the writer will quote from Guillaume's "Unites et Etalons":

> Many measurements of the density of water have been made since the beginning of the century; their results are contradictory, so that to-day it is not yet known on which side the error was committed in the construction of the kilogramme. The international commission on the meter, charged with giving a new definition of the unit of mass, decided simply to reproduce the kilogramme of the archives, without referring in any way to its theoretical definition. The density of water is, therefore, no longer considered as being, by definition, equal to unity; this constant should be deduced from the unit of volume and the unit of mass. Still the almost perfect agreement between the real value of the kilogramme and its original definition allows the density of water to be considered as rigorously equal to unity in almost all cases, which greatly simplifies calculations.
>
> The first accurate determination of the density of water was made by Lefèbvre-Gineau for the very construction of the kilogramme. This determination gave the density of water as unity at 4° C. But a thorough investigation by Broch of Lefèbvre-Gineau's work gives the weight of the standard kilogramme as being 0.1 gramme too heavy, hence the density of water is about 1-10,000 less than unity. But, in studying the lineal measures used by Lefèbvre-Gineau, it would appear that the probable error in his work is about equal to the error which he found in the weight of the kilogramme.
>
> Later investigations show that the above is rather too large a reduction, and that the density of water is probably 0.99995 or 0.99996. The question is still under study. It is one beset by many difficulties, the most important lying in the measurement of the lineal dimensions of the bodies used in the experiments. An error of only 2-10,000 of a millimeter (0.0000079-in.) being sufficient to produce discordant results.
>
> If the opponents of the system have nothing better than such objections as the two just given on which to base their stand, their case must surely be very weak.

3. Objection is made that with the metric system binary divisions cannot be written. But why write them at all? Binary divisions have no place in a decimal system. What advantage is there in writing ½ rather than .5; or ¼ than .25; or ⅛ than .125? It is mere habit to do so. Furthermore beyond 1-64 the illogical opponents of the metric system abandon their binary divisions and take to decimals.

4. Our opponents tell us that when we use the convention of writing millimeters instead of expressing them in decimals of the meter we are adopting a second unit. What difference is there between writing 113 millimeters or 113 thousandths of a meter? or between writing by an understood convention for machinery drawings 113 or, without the convention, 0.113. It is all the same thing, and the objection so called becomes mere carping founded on either ignorance or misunderstanding.

5. A last claim made by our opponents is that because the metric system is demical the arc, to be consistent, should be divided centesimally. Why? What has the circle, or its divisions, to do with a straight line? If the circumference of the circle could be expressed in terms (not approximate but exact) of its diameter the claim might have some weight, but as the circumference is incommensurable with its diameter the point of the objection to the metric system is not clear. That it would be a great advantage and convenience to divide the circumference into 400° the writer firmly believes.*

There will be some difficulties, beyond doubt, in applying the system. That they will be as great as the opponents of the system try to make them appear is wide of the fact. When manufacturers say that their whole plant will become useless by the change, the statement may be laid down to an endeavor to affect opinion by means of high coloring. A boring machine does not inquire whether a bit will cut a hole of one inch or only 25 millimeters (0.984 in.). It will do the one as well as the other. The bits have to be changed, not the machine. In a planing machine it is doubtful whether anything of importance has to be changed. A shaving of 0.118-in. (3 millimeters) can be removed by the cutter as easily as one of 0.125 (⅛) inch. Many tools and many patterns would have to be replaced, but that there would have to be a clean sweep of everything the writer does not believe, nor does he believe that those who assert it believe it. Still the cry is a good one with which to influence those who do not know or think.

The writer's personal observations in Europe, at various times during the past 27 years, cause him to indorse emphatically every word in Mr. Corthell's letter. (Eng. News, Feb. 26.) He has shown contractor's drawings and pictures of American machinery and explained the working thereof, but everywhere he meets the same reply: "But we cannot use your machines; they are all built by the foot and inch." Germany is securing throughout the world, and even in France, much trade which should go to the United States, simply because she uses the metric system. And this is true in many countries where the American is liked as much as the German is disliked. If our American manufacturers could realize how far all European countries are behindhand, especially in contractors' plants for public works, and would be willing to make machines which contractors could use, they would find a large field to cultivate. A German machine, however, can be repaired nearly all over Europe as easily as in Germany. An American machine can be repaired nowhere, except possibly in England.

F. A. Mahan.

51 Avenue Montaigne, Paris, France, Feb. 25, 1903.

*A French engineer who has examined this article tells the writer that the 100° quadrant divided into 100 minutes and 100 seconds is coming more and more into use in France. The difficulty in the way of its more rapid advance is this: The tables of sines and tangents for the centesimal system have not yet been prepared with the great care and accuracy which have been bestowed on those of the 90° system.

## A Table of the Capacity of Steel Plate Girders.

Sir: I enclose a table giving the capacity in ft.-lbs. of bending moment for 72 different sections of steel girders. By interpolation for the odd sixteenths of an inch in thickness of flange angles this number can be doubled.

For those of our friends who have been using "the same," or a "better" set of tables for the past 25 to 100 years, I will state that I have not, in my short experience, seen or heard of them. I am, however, open to suggestions.

Hoping that these tables may be of some use to the profession, I remain,

Yours truly,

Frank L. Batchelder, M. W. S.E.,
Asst. Engr., C. R. R. R.

Houghton, Mich., March 17, 1903.

CAPACITY OF STEEL GIRDERS IN FOOT-POUNDS OF BENDING MOMENT.

(This table is based on Coopers' "Railroad Bridge Specifications," and is computed for floor system girders. The working stress is 10,000 lbs. per sq. in. on net flange section, obtained by deducting 1-in. hole for ⅞-in. rivet. Weights are net + 10% to cover rivets and connecting angles. Longer leg of angles is perpendicular to web. Back to back of angles = thickness of web + ¼-in.)

| Size of angles, ins. | Web, ins. | Flange stress, lbs. | Effective depth, ins. | Bending moment, ft.-lbs. | Weight, lbs. per ft. |
|---|---|---|---|---|---|
| 5×3½×⅜ | 24 × ⅜ | 53,500 | 22.53 | 100,450 | 79.42 |
| 5×3½×½ | 24 × ⅜ | 70,000 | 22.43 | 130,840 | 93.50 |
| 5×3½×⅝ | 24 × ⅜ | 85,900 | 22.35 | 160,000 | 107.58 |
| 5×3½×¾ | 24 × ⅜ | 101,200 | 22.25 | 187,650 | 120.78 |
| 5×3½×⅜ | 27 × ⅜ | 53,500 | 25.53 | 113,820 | 83.64 |
| 5×3½×½ | 27 × ⅜ | 70,000 | 25.43 | 148,340 | 97.72 |
| 5×3½×⅝ | 27 × ⅜ | 85,900 | 25.35 | 181,460 | 111.80 |
| 5×3½×¾ | 27 × ⅜ | 101,200 | 25.25 | 212,940 | 125.00 |
| 5×3½×⅜ | 30 × ⅜ | 53,500 | 28.53 | 127,190 | 87.77 |
| 5×3½×½ | 30 × ⅜ | 70,000 | 28.43 | 165,840 | 101.95 |
| 5×3½×⅝ | 30 × ⅜ | 85,900 | 28.35 | 202,940 | 116.03 |
| 5×3½×¾ | 30 × ⅜ | 101,200 | 28.25 | 238,270 | 129.23 |
| 5×3½×⅜ | 33 × ⅜ | 53,500 | 31.53 | 140,570 | 92.05 |
| 5×3½×½ | 33 × ⅜ | 70,000 | 31.43 | 183,370 | 106.13 |
| 5×3½×⅝ | 33 × ⅜ | 85,900 | 31.35 | 224,410 | 120.21 |
| 5×3½×¾ | 33 × ⅜ | 101,200 | 31.25 | 263,540 | 133.41 |
| 6×4×⅝ | 30 × ⅜ | 64,700 | 28.37 | 152,961 | 96.23 |
| 6×4×½ | 30 × ⅜ | 85,000 | 28.27 | 200,245 | 113.39 |
| 6×4×⅝ | 30 × ⅜ | 104,700 | 28.19 | 245,957 | 130.11 |
| 6×4×¾ | 30 × ⅜ | 123,800 | 28.09 | 289,795 | 145.95 |
| 6×4×⅜ | 33 × ⅜ | 64,700 | 31.37 | 169,136 | 100.41 |
| 6×4×½ | 33 × ⅜ | 85,000 | 31.27 | 221,496 | 117.57 |
| 6×4×⅝ | 33 × ⅜ | 104,700 | 31.19 | 272,133 | 134.29 |
| 6×4×¾ | 33 × ⅜ | 123,800 | 31.09 | 320,745 | 150.13 |
| 6×4×⅜ | 36 × ⅜ | 64,700 | 34.37 | 185,311 | 104.63 |
| 6×4×½ | 36 × ⅜ | 85,000 | 34.27 | 242,745 | 121.79 |
| 6×4×⅝ | 36 × ⅜ | 104,700 | 34.19 | 298,307 | 138.51 |
| 6×4×¾ | 36 × ⅜ | 123,800 | 34.09 | 351,695 | 154.35 |
| 6×4×⅜ | 39 × ⅜ | 64,700 | 37.37 | 201,487 | 108.83 |
| 6×4×½ | 39 × ⅜ | 85,000 | 37.27 | 263,995 | 125.99 |
| 6×4×⅝ | 39 × ⅜ | 104,700 | 37.19 | 324,482 | 142.71 |
| 6×4×¾ | 39 × ⅜ | 123,800 | 37.09 | 382,646 | 158.55 |
| 6×4×⅜ | 42 × ⅜ | 64,700 | 40.37 | 217,661 | 113.04 |
| 6×4×½ | 42 × ⅜ | 85,000 | 40.27 | 285,246 | 130.20 |
| 6×4×⅝ | 42 × ⅜ | 104,700 | 40.19 | 350,658 | 146.92 |
| 6×4×¾ | 42 × ⅜ | 123,800 | 40.09 | 413,597 | 162.75 |
| 6×6×⅜ | 36 × ⅜ | 79,700 | 32.97 | 218,970 | 115.63 |
| 6×6×½ | 36 × ⅜ | 105,000 | 32.89 | 287,930 | 136.75 |
| 6×6×⅝ | 36 × ⅜ | 129,700 | 32.79 | 354,310 | 156.99 |
| 6×6×¾ | 36 × ⅜ | 151,300 | 32.69 | 412,130 | 176.79 |
| 6×6×⅜ | 39 × ⅜ | 79,700 | 35.97 | 238,890 | 119.83 |
| 6×6×½ | 39 × ⅜ | 105,000 | 35.89 | 314,180 | 140.95 |
| 6×6×⅝ | 39 × ⅜ | 129,700 | 35.79 | 386,730 | 161.19 |
| 6×6×¾ | 39 × ⅜ | 151,300 | 35.69 | 449,960 | 180.99 |
| 6×6×⅜ | 42 × ⅜ | 79,700 | 38.97 | 258,810 | 124.02 |
| 6×6×½ | 42 × ⅜ | 105,000 | 38.89 | 340,430 | 145.14 |
| 6×6×⅝ | 42 × ⅜ | 129,700 | 38.79 | 419,160 | 165.38 |
| 6×6×¾ | 42 × ⅜ | 151,300 | 38.69 | 487,790 | 179.83 |
| 6×6×⅜ | 45 × ⅜ | 79,700 | 41.97 | 278,740 | 128.24 |
| 6×6×½ | 45 × ⅜ | 105,000 | 41.89 | 366,680 | 149.36 |
| 6×6×⅝ | 45 × ⅜ | 129,700 | 41.79 | 451,590 | 169.60 |
| 6×6×¾ | 45 × ⅜ | 151,300 | 41.69 | 525,610 | 189.40 |
| 6×6×⅜ | 48 × ⅜ | 79,700 | 44.97 | 298,670 | 132.44 |
| 6×6×½ | 48 × ⅜ | 105,000 | 44.89 | 392,930 | 153.56 |
| 6×6×⅝ | 48 × ⅜ | 129,700 | 44.79 | 484,010 | 173.80 |
| 6×6×¾ | 48 × ⅜ | 151,300 | 44.69 | 563,430 | 193.60 |
| 6×6×⅜ | 51 × ⅜ | 79,700 | 47.97 | 318,590 | 139.41 |
| 6×6×½ | 51 × ⅜ | 105,000 | 47.89 | 419,180 | 160.53 |
| 6×6×⅝ | 51 × ⅜ | 129,700 | 47.79 | 516,430 | 180.77 |
| 6×6×¾ | 51 × ⅜ | 151,300 | 47.69 | 601,260 | 200.57 |
| 6×6×⅜ | 54 × ⅜ | 79,700 | 50.97 | 338,510 | 146.89 |
| 6×6×½ | 54 × ⅜ | 105,000 | 50.89 | 445,430 | 162.01 |
| 6×6×⅝ | 54 × ⅜ | 129,700 | 50.79 | 548,860 | 182.25 |
| 6×6×¾ | 54 × ⅜ | 151,300 | 50.69 | 639,090 | 202.05 |
| 6×6×⅜ | 57 × ⅜ | 79,700 | 53.97 | 358,440 | 145.11 |
| 6×6×½ | 57 × ⅜ | 105,000 | 53.89 | 471,680 | 165.23 |
| 6×6×⅝ | 57 × ⅜ | 129,700 | 53.79 | 581,290 | 186.47 |
| 6×6×¾ | 57 × ⅜ | 151,300 | 53.69 | 676,910 | 206.27 |
| 6×6×⅜ | 60 × ⅜ | 79,700 | 56.97 | 378,370 | 149.34 |
| 6×6×½ | 60 × ⅜ | 105,000 | 56.89 | 497,930 | 170.45 |
| 6×6×⅝ | 60 × ⅜ | 129,700 | 56.79 | 613,710 | 190.70 |
| 6×6×¾ | 60 × ⅜ | 151,300 | 56.69 | 714,730 | 210.50 |

## MECHANICAL FILTER PLANT OF THE EAST JERSEY WATER CO., LITTLE FALLS, N. J.

The largest and most complete and interesting mechanical filter plant thus far erected was put in partial operation at Little Falls, N. J., on Sept. 4, 1902. It was built by the East Jersey Water Co., to treat water from the Passaic River now supplied to Paterson and Passaic, and which eventually will be sent to Montclair and other suburban New Jersey towns. The plant has a nominal daily capacity of 32,000,000 gallons, and besides the 32 rectangular filters of 1,000,000 gallons capacity each there is a 1,750,000-gallon coagulating and subsiding basin and two clear water basins of a combined capacity of 3,500,000 gallons. The plant as originally designed, and essentially as built, was described at length in Engineering News of May 9, 1901, in an article by Mr. Geo. W. Fuller, Assoc. M. Am. Soc. C. E., now of Hering & Fuller, 170 Broadway, New York. A more detailed description of the plant, and particularly of its operation, was given by Mr. Fuller in a paper* read before the American Society of Civil Engineers on April 1. This article is based on that paper, and for the illustrations accompanying it we are also indebted to the society.

Credit for the design and construction of the plant can best be given by quoting from Mr. Fuller's paper, as follows:

> The Water Co., in June, 1900, requested the New York

*The Filtration Works of the East Jersey Water Co., at Little Falls, N. J. Proc. Soc. C. E., Vol. XXIX., p. 173.

Filter Manufacturing Co. and the Continental Filter Co., shortly afterward consolidated as the New York Continental Jewell Filtration Co., to submit outline plans and general estimates of cost for this project. These were submitted to the Water Co. in September, 1900, and were referred to the writer, who was requested to supervise for the Water Co. the preparation of detailed plans by the Filtration Co., and also to prepare specifications. It is gratifying to record that the Water Co. instructed the writer not to spare expense in making the plant capable of giving thoroughly efficient service. Mr. Charles L. Parmelee, Chief Engineer of the Filtration Co., had the immediate charge of the preparation of the plans. Upon their construction features the writer had the assistance of W. B. Fuller, M. Am. Soc. C. E., who, later, was appointed by the Water Co. as Resident Engineer in charge of the construction work. The entire project was designed and built under the direction of J. Waldo Smith, M. Am. Soc. C. E., Chief Engineer and Superintendent of the East Jersey Water Co. With the exception of the machinery and the operating devices, which were designed by the Filtration Co., the design of this plant was the result of numerous conferences and discussions between the representatives of the Water Co. and the Filtration Co.

These works, with few exceptions, were built by contract. All excavation and masonry work in the coagulating basin and clear-water basin, grading, etc., was done by the T. A. Gillespie Co., of New York and Pittsburg; the filter tanks and the entire superstructure were built by Mr. Joseph Sharpe, of Paterson, sub-contractor under the Gillespie Co., and the entire equipment of the filters, including piping, valves, strainer systems, machinery and devices for applying the coagulant and operating the filters, was furnished and erected by the Filtration Co.

As shown by our previous article, one of the unique features of the plant is the use of concrete and Ransome reinforced concrete for nearly the whole plant, except the roofs, doors and windows of the buildings. The concrete walls of the coagulating basin are some 40 ft. high, and the main walls of the clear water basins and filter tanks, just above, are about the same height. The filter tanks, 15 × 24 ft., × 8 ft. deep, are described by Mr. Fuller as continuous boxes of concrete, reinforced with twisted steel rods in each direction. They are beneath the level of the main floor of the plant, and above the clear water basins, and a part of their area is covered by the floor just named. The general course of the water through the filter plant is thus described in the paper:

River water is taken from the head-race canal, and is delivered to the filtration works through a 66-in. steel main discharging into a concrete stand-pipe, 10 ft. in diameter, located at the north end of the coagulating basin. In this stand-pipe the water is treated with a solution of coagulant, and, after thorough mixing by the natural agitation in the stand-pipe, it passes from the bottom of the same into the coagulating basin and thence to the south end, where, near the surface, it is collected in a perforated pipe, through which it passes to the filters. It is possible to by-pass the coagulating basin, and deliver the water from the upper portion of the stand-pipe through a pipe connecting with the main inlet pipes to the filters. After passing through the filters the water enters the clear-water basin, from which it flows through a 66-in. steel suction main, encased in concrete and leading to the main pumps. Branch suction pipes extend from the pump in either compartment of the clear-water basin, with necessary valves in an effluent-valve well, located outside the basin where the branches join the main line. Filtered water from the entire plant may be taken from either compartment independently of the other.

Necessary facilities are also provided for cleaning out the coagulating basin, including a pump located in a sludge well to the south of the basin. Arrangements are made by which at times of low water, if need be, the sediment removed from the basin, as well as that from the discharged wash-water, may be settled out in a catch-basin to the east of the filter plant.

APPLIANCES FOR PREPARING AND REGULATING THE COAGULANT.—The sulphate of alumina used as a coagulant is dissolved in small tanks, placed below the storeroom on the main floor, from which the chemical is dumped through chutes. The dissolving tanks are provided with slowly moving bronze stirrers, and the solutions flow from the tanks through cement pipes to the mixing tanks, which are of concrete steel, 16 ft. in diameter and 17 ft. deep, with capacities of about 25,000 gallons each. The saturated solutions of sulphate of alumina are here diluted as desired, filtered water being used for the purpose, and the liquid being kept in motion by air from rotary belt-driven blowers, supplied at a rate of about 75 cu. ft. of free air per minute through a special system of pipes in the bottom of each tank.

Bronze centrifugal pumps, direct-connected to electric motors, lift the solution to small weir-tanks, 13 ft. above the water line in the coagulating basin. These tanks are always kept full, so as to give a constant discharge head. The further regulation of the coagulant is described as follows by Mr. Fuller:

As the solution leaves the orifice tank it flows into a concrete funnel on the mouth of a 2-in. pipe, which conveys it to the discharge manifold. The latter is located in the mouth of the main inlet pipe, and is a wrought-iron frame holding a grid of ½-in. brass pipes tapped into a 2-in. brass header. The branches are 6 ins. apart, and each one has ¼-in. holes, on 6-in. centers, through which the coagulant solution is discharged. The total number of holes in this discharge manifold is 100. The manifold is hung in vertical slides from the stand-pipe, and can be raised or lowered readily by means of wire ropes and a windlass.

At the bottom of the orifice tank there is a rectangular slot made of hard rubber and having a fixed width of ¼-in. By means of a slide, which works over the face of this orifice, the length of this opening may be adjusted from 0 to 6 ins. Adjustment is made by a rod, which connects with the slide in the tank and passes through the side of the tank to a frame. A milled wheel in a fixed bearing, with a fine adjusting thread, is used to move the orifice plate. A pointer on the rod, over a fixed scale, indicates the length of the opening and facilitates adjustment. The orifice is calibrated for the different divisions of the indicator, and a diagram is used to indicate the corresponding flow.

In the original design provision was made for a series of orifice plates, each plate to contain 32 orifices, corresponding to the number of filters. In operation it was the intention to plug as many of these orifices as there

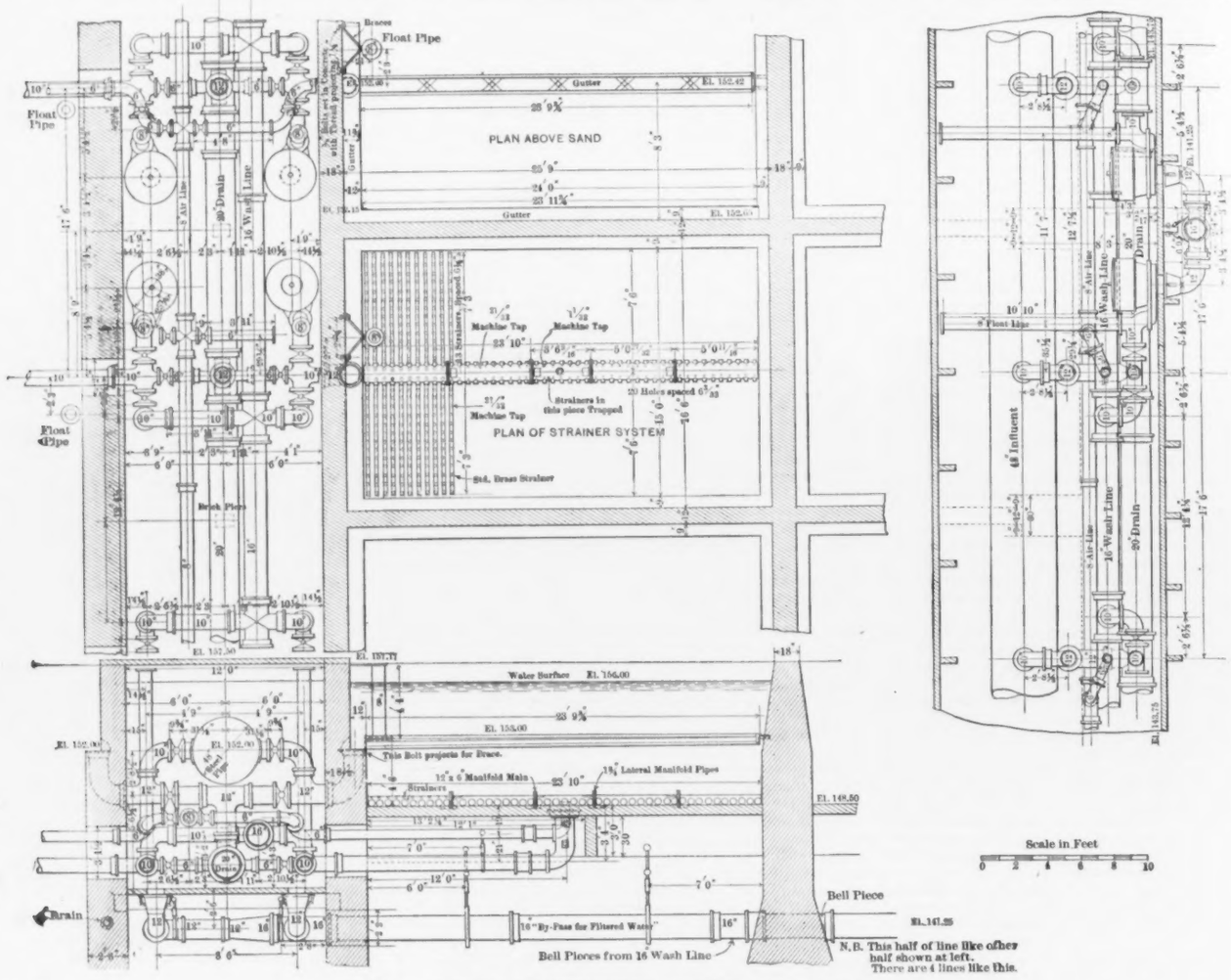



FIG. 1. DETAILS OF MECHANICAL FILTER, LITTLE FALLS, N. J.

were filters out of service, and to have different-sized orifices in each of the series of plates, so as to provide a reasonable range in the rate of application of the sulphate of alumina to the water treated. This design was abandoned, partly on account of the interference with each other of the orifices placed fairly near together, and partly on account of changes in the edges of the orifices due to fine granular deposits which would probably accumulate there.

The device which was built is moderately satisfactory, but has given some trouble, chiefly due to inability to secure at all times a volume of flow corresponding to that indicated by the length of opening of the orifice. Some difficulties of a clogging nature were encountered at first, due principally to splinters from the barrels, which passed through the screens first used in the mixing tanks.

In each of the mixing tanks is an automatic recording gage, which makes a constant record of the depth of solution. For periods of several hours, the differences in the level of the solution in the tank, as read from the gage, give a satisfactory record of the quantity of solution used. Owing to the size of the tanks, however, this does not give an immediate detection of a change in the rate of flow. This information is now obtained by a float in the orifice tank, which rings a gong as soon as the level of the solution in the small tanks drops 1 in. That is, if the flow is interrupted, in degree equivalent to the full flow for less than one minute, the fact is announced by this gong. Changes in the rate of application of the coagulant solution are secured ordinarily by the indicator connected with the calibrated screw for changing the length of the orifice, but at intervals this is checked by means of a small measuring tank holding about 30 gallons, and through which the solution passes on its way to the discharging manifold in the mouth of the main inlet pipe.

Soda ash is used at times of heavy flood and low alkalinity of the river water. The chemical is placed on the false bottom of a small tank, and water, preferably hot, is admitted from below. The solution is admitted to the main inlet, about 175 ft. in front of its entrance to the coagulating basin.

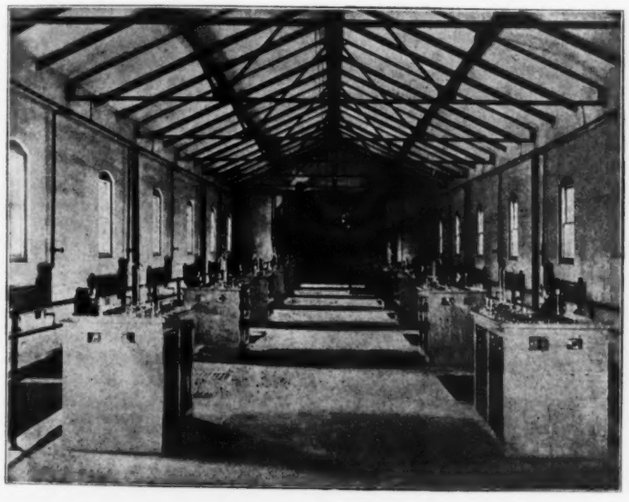


FIG. 2. VIEW OF OPERATING ROOM, LITTLE FALLS FILTRATION PLANT.

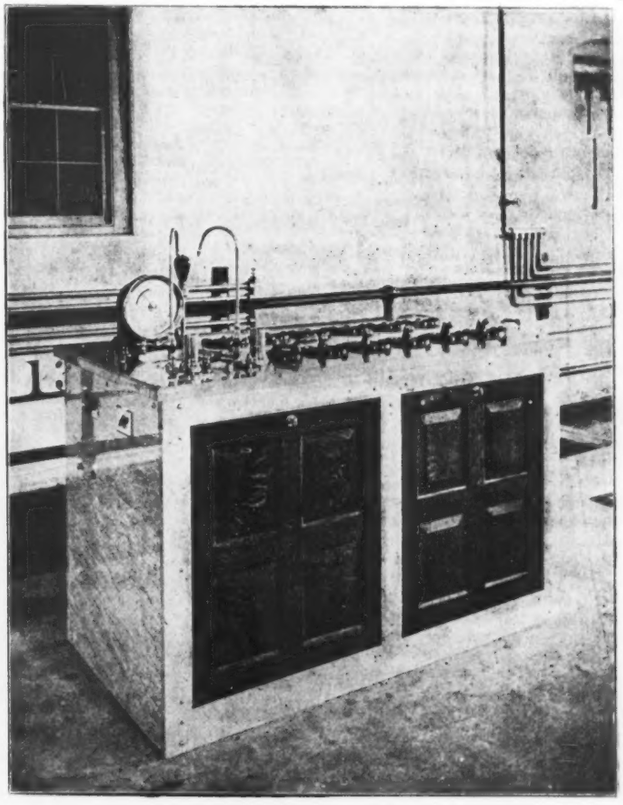


FIG. 3. VIEW OF OPERATING TABLE, LITTLE FALLS FILTRATION PLANT.

THE FILTERS.—Details of a filter tank are shown by Fig. 1. The 1¾-in. laterals are 6 3-32 ins. c. to c., and into the header and laterals are screwed Continental brass strainers, 6¼ ins. c. to c., 1,316 to a tank. The strainer connections have special provision for the admission of the air used to agitate the sand in washing the filters, all of which is explained in detail by Mr. Fuller.

At ordinary rates, the filtrate passes out through the laterals with a velocity of about 1 ft. per sec., and through the main header at 2 ft. per sec. The exit area of the orifices is 0.37-in. per sq. ft. of filtering surface. The combined friction and velocity head, or total loss due to the strainer system and outlets, when the filters are working at their normal rate of two gallons per sq. ft., is about 0.7-ft.

The filtering materials are as follows, from the bottom up: (1) 2 ins. broken quartz, which has passed through a screen with 4 meshes to the linear inch and been retained on an 8-mesh screen, and which has an effective size of 4.4 mm., and a uniformity coefficient of 1.30. (2) 5 ins. of quartz screened between 8 and 12 meshers per lin. in., with an effective size of 2 mm., and a uniformity coefficient of 1.45. (3) 30 ins. of sand of varying quality in the several filters thus far put in use, with effective sizes ranging, by filters, from 0.46 to 0.35 mm. and uniformity coefficients from 1.50 to 1.32.

In 30 ins. of clean sand, with an effective size of 0.41 mm., and a uniformity coefficient of 1.45 (normal size), the loss of head due to friction is 1.1, 1.7, and 2.6 ft., respectively, for rates of 80, 125, and 185 millions of gallons per acre daily.

Washing the filters is effected by first agitating the sand layer by means of low pressure air, supplied from a No. 3 Root rotary blower of 1,500 cu. ft. per min. capacity (free air), under 5 lbs pressure. The air is usually applied for three minutes, at the rate of 1,000 cu. ft. per min., or 20 to 25 cu. ft. of free air per sq. ft. of filter, under 3 lbs. pressure, with water standing 4 ins. above the top of sand, or 8 ins. below the overflow gutters. This air raises the sand about 3 ins., but does not float the entire sand bed, as does the wash water. Next filtered water is admitted, also from below, under a pressure of about 25 ft. in the strainer system, and at a rate of about 5½ gallons per sq. ft. of filter. This is continued until the wash water runs fairly clear. The wash water raises the sand about 3 ins., or within 9 ins. of the overflow gutter, with only a trifling loss of sand. Generally, air is supplied a second time, for about a minute, and then water is admitted once more, to drive out the air and complete the cleansing. The washing process takes about twelve minutes.

Weston effluent controllers are used to regulate the rate of filtration. These consist essentially of a moving orifice operated by a float in an open compartment. The water enters the controller through butterfly valves, which are operated by the float. The action of these controllers is to maintain a uniform rate of discharge, independent of the head on the outlet pipe. Accordingly, the filters are always operated during filtration with the valve on the outlet pipe wide open, and the flow is controlled automatically by this device.

Orifice discs of three different sizes are provided with each controller, giving yields of about 1,000,000, 1,250,000 and 1,500,000 gallons per filter per 24 hours, respectively. There are also a few special discs to give a daily yield of 650,000 gallons.

The head lost in these controllers, as measured from the water level in the outlet stand-pipe (when the float in the controller is seated) to the top of the pipe gallery floor, is about 2.5, 3.0, or 4.0 ft., when the yields of the filters are 650,000, 1,000,000 or 1,500,000 gallons daily, respectively.

Hydraulic valves are used on all the filter piping. Levers to operate the valves are placed on the marble operating tables shown in the views, Figs. 2 and 3. Loss of head gages, buttons for electrically starting and stopping the air and wash water pumps, and means for collecting samples of both unfiltered and filtered water are also provided at each operating table, thus enabling the attendant to control each filter without moving away from it, and with practically no manual labor. The sample-collecting pipes are supplied by means of ¼-in. centrifugal pumps, driven by small Pelton water wheels, the suction of one pump being connected with the filter inlet, and of the other with the filter outlet.

OPERATION AND RESULTS.—Mr. Fuller was given the general oversight of the plant for the first year of its operation, beginning Sept. 4, 1902, and for the first six months of that period Mr. Geo. A. Johnson was in immediate charge. Advantage is being taken of the opportunity thus presented to secure full records of the results obtained under different conditions; and, since only half of the filters were put in use at the start, it was decided to try various grades of sand, and to use no air in washing some of the filters. Most of the filters have been operated at a rate of 125,000,000 gallons per acre per day, including those containing coarse, fine, and normal sand. Two have been run at an 80,000,000, and two at a 185,000,000-gallon rate; both these contain sand of normal size.

The force employed has, naturally enough, been relatively larger at the outset than it is expected to make it later on. It has in number nine men, besides Mr. Johnson, three of whom were technically trained. When the plant goes into full operation it is expected that "the total force employed with 12-hour shifts, would be ten men, including the man in charge and his principal assistant."

The sulphate of alumina employed contains no free sulphuric acid, practically no sedimentary matter, about 17% of water-soluble aluminum oxide, and traces of iron. It cost about 1 ct. per lb. Up to Feb. 1, 1903, the average quantity used was 1.30 grains per gallon of river water, or 1.35 grains per gallon of filtered water, the range in the quantity applied varying from 0.29 to 2.01

TABLE I.—Summary of Results Showing the Efficiency of the Coagulating Basin.

| Month. | Period of coagulation and subsidence, hrs. | Turbidity. River water. | Turbidity. Coag. basin eff. | Color. River water. | Color. Coag. basin eff. | Amorphous matter. River water. | Amorphous matter. Coag. basin eff. | Bacteria. River water. | Bacteria. Coag. basin eff. |
|---|---|---|---|---|---|---|---|---|---|
| September, 1902 | 3.1 | 10 | 6 | 31 | 20 | ..... | ..... | 5,400 | 3,900 |
| October | 3.3 | 6 | 5 | 52 | 31 | 1,100 | 380 | 3,800 | 650 |
| November | 3.2 | 5 | 4 | 45 | 28 | 280 | 80 | 3,500 | 1,100 |
| December | 2.9 | 7 | 4 | 44 | 24 | 450 | 210 | 5,800 | 1,800 |
| January, 1903 | 2.8 | 6 | 5 | 31 | 21 | 200 | 115 | 4,000 | 1,700 |

grains, according to the amount of color and amorphous matter in the raw river water. From Dec. 17 to 30, inclusive, from 0.16 to 0.63 grains of soda ash per gallon of water was used, the average being 0.49. It was then necessary to analyze the river water "from time to time through the 24 hours." The aim was to ensure 5 parts per 1,000,000 of alkalinity in the filtrate, or an amount (surplus) capable of dissolving over ½ grain per gallon of sulphate of alumina. The efficiency of the coagulating and subsiding basin is shown by Table I.

On Nov. 10, about 8 ft. of sludge was removed from the coagulating basin, and on Jan. 13, about 5 ft. was removed. On the latter occasion it was found that the sludge contained about 87% of water and 13% of dry solids, and of the latter some 27% was aluminum hydrate. Some decomposition of the sludge was observed at both cleanings, particularly in November, but nothing like septic action.

The quantity of wash water used, up to Feb. 1, averaged 4.2% of the water treated, and the average service between washings was 9.68 hours, with ordinary ranges of from 6 to 18 hours per run. The two filters operated without the use of air in washing indicate that the air is beneficial, but further observations are considered essential to a comprehensive discussion of the effect of the air.

The electric horse power required to operate the various devices is as follows: Wash water pumps, 75; blower, 45; chemical feed pump, 2; sludge pump, 40; soda pump, 1; main shafting, 10; effluent gate valve, 5; total, 178.

The bacterial results depend "essentially upon the quantity of coagulant applied." A series of tables showing daily results is given in Mr. Fuller's paper; also a statement by months, which is reprinted here as Table II., with two columns relating to color added:

The reduction of coagulant in January was for the purpose of determining its effect upon the bacterial results.

The aim is to keep the color below 10, but it is found that practically as much coagulant is required to reduce the color to 10 as to 5; moreover, a color of 20 is "practically unnoticeable to the consumer."

The turbidity usually ranges from 0 to 2, now and then reaching 3, so practically all turbidity is removed.

The organic matter, in parts per 1,000,000, is about 0.121 of albuminoid ammonia in the river water, and 0.075 in the filtered water; oxygen consumed, 6.3 and 1.6, respectively; giving removal of 38% of albuminoid ammonia, and 75% of oxygen consumed.

The comparative hardness of the natural and the filtered water, in parts per 1,000,000, is as follows: Temporary, 23 and 15; permanent, 12 and 19; total, 35 and 34.

No undecomposed sulphate of alumina has been found in the filtered water, and only occasional traces of aluminum hydrate have been found.

Provided the applied water

is well coagulated, satisfactory results will follow with a rate of filtration at least as high as 185,000,000 gallons per acre per 24 hours, and with an inadequately coagulated water good results cannot be obtained at rates of 80,000,000 gallons per 24 hours, or much less.

The bacterial results are not "materially affected by the rate of filtration." A 20 weeks' average of figures designed to show the effect of the rate of filtration and the period of service on the percentage of wash water gives the following figures:

| Relative rate of filtration. | Hours service. | Volume filtered per run. | Per cent. of wash water. |
|---|---|---|---|
| High | 7.52 | 470,000 | 3.8 |
| Normal | 10.18 | 425,000 | 4.1 |
| Low | 12.93 | 358,000 | 4.4 |

Cost items, Mr. Fuller stated, could not be given, at present, in as much detail as is desirable but the construction cost per million gallons of nominal capacity was as follows:

| | |
|---|---|
| Coagulating basin and clear-water basin, including piping within the walls and grading the grounds | $5,400 |
| Supply and suction piping outside the structures. | 800 |
| Filter tanks, including covers | 1,600 |
| Main building and wings, including floors, piers and entire superstructure, except the last item | 2,000 |
| Filter equipment, complete, including machinery within the buildings | 4,800 |
| Power equipment and outside wiring | 800 |
| | $15,300 |

In discussing the paper at the date of its presentation, Mr. J. Waldo Smith, M. Am. Soc. C. E., stated that since Feb. 1 the second application of air and wash water had been omitted, except once a week, and that the wash water had fallen from 4.2 to 3%. The amount of sulphate of alumina used since Feb. 1 has been about one grain per gallon, and later in the season this will be still lower. The cost of operation for the month of March was about $3.19 per 1,000,000 gallons, but when the plant is operated at full capacity it is hoped that this will be reduced to about $2.50.

## EQUATED TONNAGE RATES FOR FREIGHT LOCOMOTIVES; METHODS OF TEST AND CALCULATION.*

By Max H. Wickhorst,† Jun. M. Am. Soc. M. E.

The work of locomotive rating consists of two main divisions: 1, to determine the maximum working tractive force of the engine, and 2, to balance this with an equal amount of total train resistance on the ruling grade.

### TRACTIVE FORCE.

For figuring the maximum tractive force that an engine may develop at the tender draw bar on level track for simple engines, we used the following formula:

$$T F = \frac{.85\ P\ d^2 s}{D},$$

Where P = maximum boiler pressure in lbs. per sq. in.
d = diameter of cylinder in inches.
s = stroke in inches.
D = diameter of driver in inches.

This formula assumes that the mean effective pressure in the cylinders at full stroke is 92% of the maximum boiler pressure and that 92% of the work done by the cylinders is transmitted back to the draw bar behind the tender.

For compound engines we use the following formulas, working compound:

$$\text{Two-cylinder compounds, } T F = \frac{.85\ P\ d_l^2\ s}{D\ (r+1)}$$

$$\text{Four-cylinder compounds, } T F = \frac{1.7\ P\ d_L^2\ s}{D\ (r+1)}$$

$$\text{Two-cylinder compounds working simple, } T F = \frac{.85\ P\ d_h^2\ s}{D}$$

(Presumably r represents the ratio of the cylinders.—Ed.)

The only four-cylinder compounds that we have are of the Vauclain type, and when worked so-called "simple" they work compound as before, but in addition a small amount of steam is let direct into the low-pressure cylinder, which has the effect of increasing the tractive force an amount depending on the speed. At speeds of 10 miles per hour this increase amounts to about 2,000 lbs., according to one or two trials we made.

### TRACTIVE FORCE ON GRADES.

On a grade the tractive force of an engine is less due to the fact that it must lift its own weight up the grade, which absorbs some of the work performed by the cylinders and leaves less to develop at the drawbar. The amount to be deducted for this engine grade resistance is found by the following formula:

Engine grade resistance = 20 W G;
Where W = weight of engine and tender in tons; and
G = grade in per cent.

### WORKING TRACTIVE FORCE.

Having obtained the maximum tractive force, a certain allowance must be made for small drops in steam pressure as affecting the tractive force, and for an occasional stuck brake, excess of billed over actual tonnage, etc., as affecting the train resistance. On runs where the maximum grade is only a small portion of the total distance, and the run comparatively light, we took 90% of the maximum available tractive force as the maximum working tractive force on the ruling grade, thus allowing 10% for the above mentioned contingencies. With a slow freight train under these conditions the minimum speed would be about 8 or 10 miles per hour. Where the run as a whole is hard and the grades long, we took 80%. This would allow the engine to handle the train conveniently on the ruling grade and yet not have great excess of tractive force to spare. For convenience in making rate schedules and calculating, we have made a table showing the maximum available tractive force of an engine on the level; 90% and 80% of this, and also these three with the engine grade resistance subtracted for grades from 0.1% to 3%.

### TRAIN RESISTANCE.

Train resistance consists of three primary resistances: 1, acceleration resistance; 2, grade resistance; 3, friction. Acceleration and grade resistance are elementary resistances, dependent only upon the amount of tonnage and not upon the form of the tonnage, such as in empty or loaded cars, etc. Friction is a compound resistance dependent upon a good many conditions, such as kind of cars, load in cars, condition of trucks, wind, curves, etc. The composition of train resistance is shown below:

- Train resistance
  - Acceleration resistance depends on tonnage only. — 20 lbs. per ton for 1% grade, or about 4 lbs. for each foot of grade.
  - Grade desistance depends on tonnage only. — (same)
  - Friction — Varies from 2½ to 12 lbs. per ton.
    - Journal. Depends on design and lubrication.
    - Rolling. Depends on solidity of roadbed.
    - Flange.
    - Curve
      - Sliding of one tread, in each pair, on the rail.
      - Flange friction.
    - Side bearings and center plates cause flange friction.
    - Wind
      - Wind against body of car.
      - Flange friction.

Note—Flange friction consists of that due to curves, side bearings and center plates, winds, etc.

In rating slow freight trains, acceleration resistance need very seldom be considered, except on momentum grades. Here it comes as negative resistance and will be considered later under the head of momentum grades.

### GRADE RESISTANCE.

This, generally, is the biggest component of the freight train resistance and is dependent only on the tonnage on any given grade. The grade resistance per ton may be figured by the formula r = 20 G, where r = grade resistance in lbs. per ton, G = grade in per cent.

### FRICTION.

As stated above the frictional resistance varies considerably. The friction expressed in pounds per ton drawbar pull increases as the speed increases, decreases as the gross weight of a car and its freight increases, and increases in a general way as the temperature of the air decreases. It varies for freight cars at freight speed between limits of about 2 lbs. per ton and 12 or more lbs. per ton.

We have prepared curves of friction resistance of freight cars at 20 miles per hour. These show the relation between the gross weight per car in tons, plotted horizontally, and the resistance per ton in pounds, plotted vertically, for three weather conditions, as follows: summer weather, or about 30° F.; cold weather, or between 10°

*Abstract of a paper read before the Western Railway Club, at Chicago, March 17.

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TABLE II.—Bacterial (and Color) Results and Principal Information Relating Thereto.
(Averages by months.)

| Month. | Sulphate of alumina, grains per gall. | Turbidity. River water. | Turbidity. Coag. basin effluent. | Turbidity. Filtered water. | Color. River water. | Color. Coag. basin effluent. | Color. Filtered water. | Amorphous matter standard units per cu. cm. River water. | Amorphous matter standard units per cu. cm. Coag. basin eff. | Bacteria, per cu. cm. River water. | Bacteria, per cu. cm. Coag. basin effluent | Bacteria, per cu. cm. Filtered water | Bacteria, per cu. cm. Removal. | Color. River water. | Color. Filtered water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| September, 1902 | 0.74 | 10 | 6 | 3 | 31 | 20 | 11 | ..... | ..... | 5,400 | 3,900 | 190 | 96.5% | 31 | 11 |
| October | 1.59 | 6 | 5 | 1 | 52 | 31 | 7 | 1,100 | 380 | 3,800 | 650 | 90 | 97.6% | 52 | 7 |
| November | 1.63 | 5 | 4 | 2 | 45 | 28 | 7 | 280 | 80 | 3,500 | 1,100 | 60 | 98.3% | 45 | 7 |
| December | 1.70 | 7 | 4 | 1 | 44 | 24 | 5 | 450 | 210 | 5,800 | 1,800 | 50 | 99.1% | 44 | 5 |
| January, 1903 | 0.84 | 6 | 5 | 0 | 31 | 21 | 5 | 200 | 115 | 4,000 | 1,700 | 110 | 97.2% | 31 | 5 |

and 30° F., and very cold weather, or below 10° F. According to the curve for summer weather the friction resistance of an empty car weighing 15 tons is 6.2 lbs. per ton, while that of a loaded car weighing 60 tons gross is 2.4 lbs. per ton.

In the curve showing friction of freight cars in cold weather, say 20° F., the friction resistance for the 15-ton car is 10 lbs. per ton, and of the 60-ton car is 5 lbs. per ton. Knowing the grade, the gross weight of a car and the general weather condition, its total resistance per ton is found by adding together the grade and friction resistances per ton as found from the above-mentioned curves.

### EQUATED TONNAGE TABLES.

Having the total resistance per ton of any given train and the maximum working tractive force of the engine, the thing is now to get sufficient tons to just make total train resistance to balance this tractive force. The number of tons that will give this total resistance will, of course, vary with the load per car and the weather conditions, increasing as the load per car increases, and decreasing as the weather conditions become more severe. For practical use we get up a rate table showing the number of tons for various numbers of cars in the train and for three weather conditions: summer, winter, and very cold. We have made several hundred such tables for grades up to 2% and for total train resistance from 10,000 lbs. to 35,000 lbs. When, therefore, we have decided on the maximum working tractive force on a given grade, we simply select from the set of tables the suitable schedule and give this as the tonnage rate schedule for the engine.

### MOMENTUM GRADES.

Where the grade is not too long, the momentum, or the work stored in the train as motion, can often be used to help get the train over the grade. A body in motion has an amount of work stored in it dependent upon its speed, and this stored work can be used to overcome the force of gravity, or in other words, take a train a certain distance up a hill. The amount of work so stored increases as the square of the speed. A body moving 30 miles per hour has sufficient work stored in it to carry it vertically upward about 30 ft.; one moving 60 miles per hour sufficient for 120 ft., etc. Therefore, a train approaching a hill at 30 miles per hour could be taken a vertical distance of 30 ft., due to the momentum, provided the friction were otherwise taken care of. On a grade 30 ft. to the mile this distance along the track would be one mile; on a 60-ft. grade, half a mile. Where this momentum is to be expended, or to run out, in a given distance, the propelling force may be expressed as a pull of so many pounds per ton, or as a certain total drawbar pull at the head end of the train, or as so much negative grade, thus cutting down the actual grade and producing a lower virtual grade. For our purpose the simplest method is to express momentum as so much negative grade and its value may be figured as per the following formula:

$$Gm = 3.5 \frac{25}{x},$$

Where Gm = equivalent grade in per cent.; V = speed in miles per hour; x = distance traversed during retardation, in feet.

Where a minimum speed of five miles per hour at top of grade is assumed, the equivalent grade would be determined as follows:

$$Gm = 3.5 \frac{V^2 - 2.5}{x}.$$

For convenience we have made a diagram from which can readily be obtained the equivalent grade in per cent., having the speed of approach and length of grade, based on this formula. Having the actual grade and the momentum expressed as equivalent grade, the virtual grade is equal to the actual minus the momentum. The actual resistance of the train is, then, that due to the virtual grade plus the friction.

### TRACTIVE FORCE AT SPEED.

Where the speed is above 8 or 10 miles per hour, the maximum tractive force cannot be sustained on account of the inability of the boiler to furnish sufficient steam, and when calculating tonnage rates on momentum grades, it is necessary to determine the average tractive force from the bottom to the top of the hill. In order to show the tractive force of our various engines at speeds up to 40 miles per hour we have still another diagram.

The tractive force shown on these curves as limited by the boiler is obtained by the following formula:

$$\text{Tractive force} = \frac{375 \times .43\ H \times E}{S}.$$

Where H equals heating surface in sq. ft.; S equals speed in miles per hour; E equals mechanical efficiency of the locomotive, that is, the ratio of the drawbar pull to the cylinder tractice force.

The expression 0.43 H gives the maximum cylinder HP. of the locomotive assuming a maximum evaporation of 12 lbs. of water per sq. ft. of heating surface per hour, and a cylinder water rate of 28 lbs. of water per HP.-hour. This is a formula given by Prof. W. F. M. Goss and agrees well with the results of our locomotive tests, so we have adopted it. The expression

$$\frac{375 \times .43\ H}{S}$$

converts horse-power into cylinder tractive force. The value of E or mechanical efficiency of the locomotive as a whole is dependent upon the speed, decreasing as the speed increases.

The tractive force shown on the above mentioned sheets of curves, at the average speed will generally be found satisfactory. We have also adopted the rule that where a grade is less than one mile long, not over 1%, and the speed of approach over 35 miles per hour, to figure it as a momentum grade. Where the speed of approach is much greater it would allow a steeper or a longer grade to be figured as a momentum grade.

In cases where we made a road test we checked up the rate as determined above, against this test.

### EQUATED TONNAGE TABLES: EXPLANATION OF METHOD.

Table I. shows the methods used in calculating equated tonnage tables. The various tonnages shown all have the same drawbar resistance of 20,000 lbs., and are calculated for a 0.5% grade at freight speeds of 20 miles per hour. The method is to make a column of gross car weights from 10 tons to 60 tons, column 1. In column 2 is then shown the resistance per ton of cars of the various gross weights. This includes the grade and friction resistances per ton. Next we divide 20,000 by the resistance per ton and get column 3, showing the various tonnages having the total train resistance of 20,000 lbs. Then by dividing the number of tons by the gross weight per car we get column 4, showing the number of cars in the train corresponding to the various tonnages. The columns of tons are then interpolated to the nearest even figures divisible by 5 and corresponding to an even number of cars divisible by 5 and placed in column 16, which is the column as finally used in rate schedules.

Having column 16, the columns 5 to 14 inclusive are obtained from columns 15 and 16 by multiplying by a suitable factor. For example, columns A are slow freight rates, columns B fast freight rates and we have taken for general use the fast rates as 80% of the slow rates. To get the tons, column 5, we multiply the tons in column 16 by 0.80 and to get the cars in column 6, we multiply column 15 by 0.80. The tons thus obtained in column 5 are in turn placed in column 17, interpolating to some even figure as before. The other columns 7 to 14 inclusive are obtained in a similar manner by using a suitable factor, selected from the table shown below the other tables.

Table II. is a sample sheet, showing the ratings from Oxford to McCook for engines of class K-4, with 72-in. driving wheels. Our idea is that each yard office should be furnished with such rates as may be needed for use by the yardmaster and conductor in making up trains, in suitable binder, so any new rate sheets can be readily inserted and the old ones thrown away.

TABLE I.—Sample Data Sheet and Method of Calculation of Equated Tonnage Rates; Burlington Route Laboratory.
(Grade, 0.5%; Resistance, 20,000 lbs.)

THE "A" RATES GIVEN BELOW ARE FOR SLOW FREIGHT. THE "B" RATES FOR FAST FREIGHT. THE "B" RATES ARE TAKEN AS 80% OF THE "A" RATES

| | TONS PER CAR | FRICTION AND GRADE RESISTANCE PER TON | TEMPERATURES: Above + 30° A TONS | Above + 30° A CARS | Above + 30° B TONS | Above + 30° B CARS | + 30° to + 10° A TONS | + 30° to + 10° A CARS | + 30° to + 10° B TONS | + 30° to + 10° B CARS | Below + 10° A TONS | Below + 10° A CARS | Below + 10° B TONS | Below + 10° B CARS | CARS | TEMPERATURES. Above + 30° A | Above + 30° B | + 30° to + 10° A | + 30° to + 10° B | Below + 10° A | Below + 10° B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 17.9 | 1117. | 116.7 | 900. | 88. | 930. | 91.5 | 740. | 72.5 | 832. | 81.5 | 665. | 65. | 100 | 1160 | ..... | ..... | ..... | ..... | ..... |
| b | 11 | 17.5 | 1143. | 103.8 | 930. | 80. | 960. | 83. | 765. | 66. | 860. | 74.0 | 685. | 59. | 95 | 1180 | ..... | ..... | ..... | ..... | ..... |
| c | 12 | 17.1 | 1170. | 97.4 | 945. | 78. | 980. | 78.8 | 780. | 62.5 | 875. | 70. | 695. | 56. | 90 | 1200 | ..... | 935 | ..... | ..... | ..... |
| d | 14 | 16.5 | 1212. | 86.6 | 960. | 72. | 995. | 74.6 | 790. | 59.5 | 890. | 66.5 | 710. | 53.2 | 85 | 1220 | ..... | 950 | ..... | ..... | ..... |
| e | 16 | 15.9 | 1257. | 78.6 | 975. | 68. | 1010. | 70.6 | 805. | 56. | 905. | 63. | 720. | 50.2 | 80 | 1245 | ..... | 970 | ..... | 835 | ..... |
| f | 18 | 15.5 | 1290. | 71.7 | 995. | 64. | 1033. | 66.4 | 820. | 54. | 920. | 59.2 | 735. | 47.3 | 75 | 1270 | 950 | 990 | ..... | 855 | ..... |
| g | 20 | 15.1 | 1324. | 66.2 | 1015. | 60. | 1053. | 62.2 | 840. | 49.5 | 940. | 55.5 | 750. | 44.4 | 70 | 1300 | 970 | 1010 | 750 | 875 | ..... |
| h | 25 | 14.4 | 1399. | 55.8 | 1040. | 56. | 1090. | 58.1 | 860. | 46. | 960. | 52. | 770. | 41.4 | 65 | 1330 | 980 | 1025 | 770 | 895 | 665 |
| i | 30 | 13.9 | 1459. | 48.0 | 1060. | 52. | 1105. | 53.9 | 880. | 43. | 985. | 48. | 785. | 38.4 | 60 | 1360 | 1015 | 1060 | 790 | 920 | 680 |
| j | 40 | 13.2 | 1514. | 37.9 | 1090. | 48. | 1130. | 49.8 | 900. | 39.5 | 1005. | 44.4 | 805. | 35.4 | 55 | 1395 | 1045 | 1090 | 815 | 945 | 700 |
| k | 50 | 12.8 | 1565. | 31.3 | 1110. | 44. | 1160. | 45.6 | 930. | 36.5 | 1030. | 40.7 | 825. | 32.5 | 50 | 1430 | 1075 | 1125 | 840 | 970 | 720 |
| l | 60 | 12.5 | 1600. | 26.7 | 1145. | 40. | 1185. | 41.5 | 945. | 33. | 1050. | 37. | 845. | 29.5 | 45 | 1465 | 1110 | 1160 | 870 | 1000 | 745 |
| m | ..... | ..... | ..... | ..... | 1175. | 36. | 1215. | 37.4 | 970. | 29.5 | 1085. | 33.4 | 865. | 26.5 | 40 | 1500 | 1145 | 1195 | 900 | 1030 | 775 |
| n | ..... | ..... | ..... | ..... | 1200. | 32. | 1245. | 33.2 | 990. | 25.5 | 1110. | 29.6 | 885. | 23.6 | 35 | 1535 | 1180 | 1230 | 935 | 1070 | 805 |
| o | ..... | ..... | ..... | ..... | 1230. | 28. | 1275. | 29. | 1010. | 23. | 1135. | 25.8 | 905. | 20.7 | 30 | 1575 | 1215 | 1270 | 970 | 1110 | 835 |
| p | ..... | ..... | ..... | ..... | 1260. | 24. | 1305. | 24.5 | 1040. | 19.8 | 1165. | 22.2 | 930. | 17.7 | 25 | 1615 | 1250 | 1310 | 1005 | 1150 | 870 |
| q | ..... | ..... | ..... | ..... | 1290. | 20. | 1340. | 20.7 | 1065. | 16.5 | 1195. | 18.5 | 950. | 14.8 | 20 | ..... | 1290 | 1350 | 1040 | 1190 | 910 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |

| GRADE % | Ratio of Tons and Cars, with Summer Weather taken as 100: + 30° to + 10° F. A TW/TC | + 30° to + 10° F. B TW/TC x .8 | Below + 10° F. A TW/TV | Below + 10° F. B TW/TV x .8 | GRADE % | + 30° to + 10° F. A TW/TC | + 30° to + 10° F. B TW/TC x .8 | Below + 10° F. A TW/TV | Below + 10° F. B TW/TV x .8 | GRADE % | + 30° to + 10° F. A TW/TC | + 30° to + 10° F. B TW/TC x .8 | Below + 10° F. A TW/TV | Below + 10° F. B TW/TV x .8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .0 | .61 | .49 | .48 | .38 | .8 | .85 | .69 | .80 | .64 | 1.5 | .91 | .73 | .87 | .70 |
| .1 | .66 | .54 | .56 | .45 | .9 | .87 | .70 | .82 | .66 | 1.6 | .92 | .74 | .88 | .71 |
| .2 | .74 | .59 | .63 | .50 | 1.0 | .88 | .70 | .83 | .66 | 1.7 | .92 | .74 | .88 | .71 |
| .3 | .77 | .62 | .67 | .54 | 1.1 | .89 | .71 | .84 | .67 | 1.8 | .92 | .74 | .89 | .71 |
| .4 | .81 | .65 | .71 | .57 | 1.2 | .90 | .72 | .85 | .68 | 1.9 | .93 | .74 | .90 | .72 |
| .5 | .83 | .66 | .74 | .59 | 1.25 | .90 | .72 | .85 | .68 | 2.0 | .93 | .74 | .90 | .72 |
| .6 | .84 | .67 | .76 | .61 | 1.3 | .90 | .72 | .86 | .69 | | | | | |
| .7 | .85 | .68 | .78 | .62 | 1.4 | .91 | .73 | .87 | .70 | | | | | |

TW—Resistance per ton for warm weather, above 30° F. TC—Resistance per ton for cold weather, from 30° to 10° F.
TV—Resistance per ton for very cold weather, below 10° F.

TABLE II.—Tonnage Rating, B. & M. R. in Nebraska—Western Division—Engine K-4, 72-in. Drivers.

(Rating "A" is for Slow Freight. Rating "B" is for Fast Freight.)

| No. Cars. | Gross Tonnage Exclusive of Way Car—Oxford to McCook—Temperatures—Above 30°—A | Above 30°—B | From 30° to 10°—A | From 30° to 10°—B | Below 10°—A | Below 10°—B |
|---|---|---|---|---|---|---|
| 100 | 1,095 | ... | ... | ... | ... | ... |
| 95 | 1,120 | ... | ... | ... | ... | ... |
| 90 | 1,145 | ... | ... | ... | ... | ... |
| 85 | 1,170 | ... | 850 | ... | ... | ... |
| 80 | 1,200 | ... | 880 | ... | ... | ... |
| 75 | 1,230 | 900 | 910 | ... | 755 | ... |
| 70 | 1,260 | 925 | 940 | ... | 780 | ... |
| 65 | 1,295 | 955 | 970 | 705 | 805 | ... |
| 60 | 1,330 | 985 | 1,000 | 730 | 835 | 605 |
| 55 | 1,365 | 1,015 | 1,030 | 760 | 865 | 630 |
| 50 | 1,400 | 1,050 | 1,065 | 780 | 895 | 655 |
| 45 | 1,435 | 1,085 | 1,100 | 820 | 930 | 685 |
| 40 | 1,475 | 1,120 | 1,130 | 850 | 965 | 715 |
| 35 | 1,520 | 1,155 | 1,175 | 885 | 1,000 | 750 |
| 30 | 1,580 | 1,200 | 1,215 | 925 | 1,040 | 785 |
| 25 | ... | 1,250 | 1,270 | 965 | 1,080 | 820 |
| 20 | ... | 1,310 | 1,330 | 1,015 | 1,135 | 865 |
| 15 | ... | ... | ... | 1,090 | ... | 920 |
| 10 | ... | ... | ... | ... | ... | ... |
| 5 | ... | ... | ... | ... | ... | ... |

## FURTHER INVESTIGATION OF THE REGULATION OF WATER SUPPLIES FOR PRIVATE FIRE SERVICE.

Some time ago the New England Water-Works Association appointed a committee to investigate the whole question of private fire services connected with public water-works systems. The committee, as finally made up, included representatives of both the water-works and the fire insurance interests, and was unable to agree on a report. A new committee was appointed a few months ago, and at the request of its chairman, Mr. F. H. Crandall, C. E., Superintendent of Water-Works at Burlington, Vt., we gladly give space to the following statement and request by the committee:

At the last annual convention of the New England Water-Works Association the following motion, made by Mr. Frank C. Kimball, Superintendent of Water-Works at Knoxville, Tenn., was unanimously passed:

That a committee of three be appointed by the President, whose duty it shall be to ask for the appointment of and to confer with similar committees from the American Water-Works and other kindred associations, and also with the various underwriters' associations, to agree, if possible, upon some adequate means of controlling private fire supplies acceptable to all parties concerned, including therein all questions relating to charges therefor and similar matters.

Messrs. F. H. Crandall, of Burlington, Vt., R. J. Thomas, of Lowell, Mass, and Elbert Wheeler, of Boston, Mass., the committee appointed in compliance with the instruction contained in the above motion, would respectfully invite correspondence and suggestions from all interested in a fair and equitable assessment of the benefit conferred in supplying fire protection by means of private fire protective systems.

The committee, so far as their investigation has progressed, find that nearly everywhere, both in case of public and private ownership, it is customary to recognize the service of the water-works to the public in the line of fire protection. A frontage tax, hydrant rental, general appropriation, or an overdraft, serving as means to secure the assessment upon the property benefited, of the cost of fire protection.

The capacity of works necessary to supply the volume of water required to make private fire services of value, the leaks habitually permitted on unmetered services, to which fire services are no exception, and the stealing, which not infrequently takes place from such services, all entail expense, to cover which an assessment should be made upon the parties directly benefited.

As in the case of schedule rate assessment, the convenience or advantage accruing from additional fixtures, together with the additional cost of the service, consti-

tutes a basis for increased assessment, so in the case of fire protection, increased benefit and increased cost of service constitute a basis for increased assessment.

The individual benefit enjoyed by the possessors of private fire protective systems is far in excess of that enjoyed by the general public, to which latter benefit, by reason of payment of taxes, all are, to a reasonable extent, entitled.

As the Hon. J. O. Hall, of Quincy, said at the 1902 convention of the New England Water-Works Association, "the individual taxpayer should not be compelled to bear any burden which, by any interpretation, can pass into an individual benefit to somebody else."

That private fire protection should yield the company, or department, furnishing it, a fair return; that a request for a service for fire or any other purpose, unaccompanied by willingness to furnish correct and trustworthy information as to the amount of water used or wasted through it is unreasonable, and that the size of services, for whatever purpose used, should be kept well within the capacity of the system to supply, without excessive loss of pressure, are conclusions easily and speedily reached. How to determine an amount constituting a fair return is a question upon which the committee find room for a greater difference of opinion.

The committee promise to all communications and suggestions their thoughtful consideration.

F. H. Crandall,
R. J. Thomas,
Elbert Wheeler,
Fire Pipe Committee, New England Water-Works Association.

Burlington, Vt., April 9, 1903.

## TEST OF AN OIL SEPARATOR.

A test of an oil separator placed on the exhaust pipe of a 250-HP. condensing Ball engine, at the Brooklyn Navy Yard, was made on March 24 by Prof. F. R. Hutton, Secretary of the American Society of Mechanical Engineers. The separator was the "Utility" oil separator, made by the Standard Steam Specialty Co., of New York city. It consists of a horizontal chamber through which the vapor passes at a moderate rate of speed and in which are hung baffles consisting of iron chains suspended in semicircular frames. The separator used in this test was a standard size for 12-in. exhaust pipe and was 40 ins. in diameter and 96 ins. long. The following is quoted from Professor Hutton's report of the results of the test:

Two tests were made. In the first one a half-pint of oil (7.75 oz., or .4843 lb.) was sent through the lubricator of the engine during an hour's run, and in the second test an entire pint or twice the amount of oil used in the first test was passed through the engine in the same time. The Utility separator was connected on a 12-in. exhaust pipe, between the engine and a surface condenser, and by means of pumps samples of water containing the oil separated from the exhaust steam were taken from the separator and samples of the condensed water were taken from the condenser after the separation of the oil. These two samples have been analyzed by a competent chemist and the quantity of oil ascertained in each sample. By comparing the amount of oil in the sample with the amount of oil which passed through the engine, and the total weight of steam condensed, and water withdrawn from the separator, the result shows that in the first test 90% of the oil was caught in the Utility separator and that of the mixture of water and oil issuing from the condenser only .0008% was oil. That is, the amount of oil in the condensed water, delivered by the condenser after separation, had only eight parts of oil in it to the million parts of water by weight.

An analysis of the discharge from the separator showed that it had the balance of the oil fed to the engines with the exception of a small and negligible loss due doubtless to adhesion of oil to metallic surfaces which the steam, by its motion, could not remove.

The second test with twice the weight of oil fed to the engine gave the same result or proportion of oil in the condensed water, indicating that the increased feed of oil did not make any difference in the effectiveness of the separation by the separator.

## A CITY ENGINEER'S CARD INDEX OF PLANS AND NOTES.

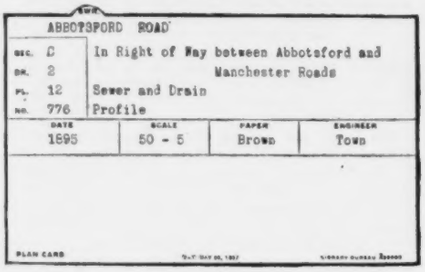
By Arthur H. Pratt,*

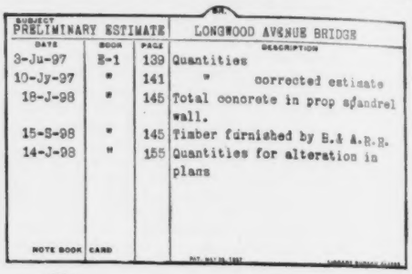
The new index for plans and notes in the Engineering Department of the Town of Brookline, Mass. (Alexis H. French, Town Engineer), was started under very favorable conditions. The department had been moved into commodious quarters, a large fireproof vault was available for storing records, and the drafting-room was entirely refurnished; opportunity was taken to inspect all of the engineering offices in the vicinity, and to consult with engineers and index-card manufacturers; hints and suggestions were accepted from many sources, and ample time was allowed to think out a logical and complete scheme. The index, as described in this article, has been proved by a year's use to be entirely practical and is so designed as to be capable of almost unlimited expansion.

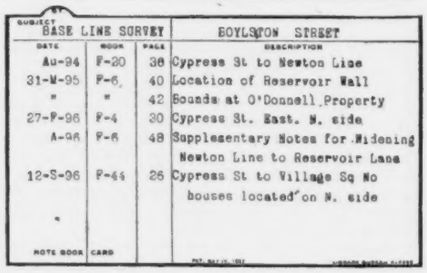
*Assistant, Engineering Department, Brookline, Mass.

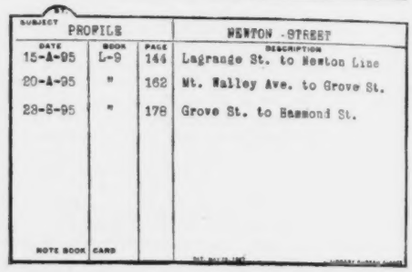
All plans are stored in the fireproof vault; flat plans in shallow drawers, and roll plans in compartments protected by roll fronts. Cases of drawers for flat plans are indicated by the first letters of the alphabet, and cases of compartments for roll plans by the last letters. Drawers or compartments in each case are numbered, and again each plan in each drawer or compartment has its own number. Plans are arranged in the drawer with No. 1 at the bottom, not more than 30 in a drawer. The plan designated as "A—14—12" is the twelfth plan from the bottom in the fourteenth drawer of case "A."

Each plan, before being assigned a drawer, is entered in the Accession Book and is given an "Accession number." The Accession Book is ruled in columns with the following headings:




SAMPLES OF INDEX CARDS FOR PLANS AND NOTE-BOOKS IN TOWN ENGINEER'S OFFICE, BROOKLINE, MASS.

Number, Section, Drawer or Compartment, Plan Title, Date of Plan, Scale, Material, Size, Field work by, Plotted or drawn by, Traced or copied by, Date completed or received and recorded, Purpose of plan and by whom ordered, Remarks.

The column headed "Number" is consecutively numbered in advance. Plans are entered in the spaces at the right of these numbers, which gives to each plan its "Accession Number." The book is a complete record of all plans made, including those that do not remain in the office. It gives at a glance the number of plans, serves as a chronological inventory, and is useful in finding a plan should its card become misplaced in the index. Another book is used as a Drawer Index, a page representing each drawer or compartment.

The card index is in two divisions. The first is for plans, the second for notes and calculations. The Standard Library Bureau card was adopted; $4.9 \times 2.95$ ins., of "medium" weight stock.

Plan cards were cut with "tabs" in nine different positions and a blank space for three more, allowing for future needs. The designations on the different tabs, beginning at the left with the class of plans covered by each designation, are shown below:

Map —Maps of large areas and districts including many streets, plans showing large drainage areas or topography.
St. —Street plans, profiles and cross-sections, sidewalks.
Sew. —Sewers.
Dr. —Surface water drains and brooks.
Pk. —Parks, playgrounds, public grounds.
Bld. —Public buildings, house measurements.
Br. —Bridges.
L. Pl.—Plans of private estates and copies of plans recorded at county registry.
Ms. —Miscellaneous not included above—water pipes, car tracks, etc.

When the miscellaneous class becomes too bulky a new tab will be used to relieve it. If the engineering work of the water department is ever combined with the engineering department a tab will be inserted for water-works.

The method of filling out the body of the plan card is best shown by the four sample cards reproduced herewith (remembering that "Pl." means number of plan in drawer, and "No." is accession number).

The plan cards are assembled in the index drawers in geographical order, largely by streets. Streets are represented by buff guide cards ("halves") alternating left and right. The principal cross streets are represented by blue guide cards ("centers"). For example, first will come a buff card labeled "BOYLSTON STREET." Immediately following will come cards for all plans extending the whole length of the street; next a blue guide card labeled "VILLAGE SQUARE" where Boylston Street begins; then follow all cards beginning at Village Square and so on in geographical order to the next cross street, "WALNUT STREET." This order is continued to the end of the street. Cards for culverts or other structures are inserted as near as possible in their geographical position. There have been 1,860 plans indexed, requiring about 2,800 plan cards and 500 guide cards.

The note-book cards have the same tab designation, with the exception of "L. Pl.," as the plan cards. The notes are still further classified in the space marked "Subject" into the following groups:

Establishing line and grade—Data for original establishment.

| | |
|---|---|
| Line and grade | —Official data for giving grades. |
| Line and grade given | —Record of field work done. |
| Base line survey | —Survey from traverse lines. |
| Survey | —Miscellaneous surveys. |
| Traverse | |
| Profiles | |
| Cross-sections | |
| Levels | —Other than profiles or cross-sections. |
| Topography | |
| Benches | |
| Location | |
| Measurements | |
| Construction | —Line and grade given—measurements for work, material, etc. |
| Borings | |
| Calculations | |
| Estimates | |
| Preliminary estimates | |
| Contractors' estimates | |
| Damages | |
| Miscellaneous. | |

All notes of a given class (indicated by tab) and subject (indicated by "Subject" space) are indexed on the same card in chronological order, the oldest entry at the top. When the card is filled a "follower" is used numbered 2, in the upper right-hand corner.

Field books, Level books, Estimate books and Calculation books are each consecutively numbered and indicated in "Book" column by initial letter and number. Note-book cards are assembled in the index drawers by streets indicated by buff guide cards. The cards under each street are arranged alphabetically by "subjects." The tabs make the class evident.

There are about 65 Field books, 50 Level books and 10 Calculation and Estimate books, requiring about 2,000 note-book cards and 400 guide cards to index the data which they contain.